THE RESOURCES AGENCY OF CALIFORNIA
Department of Water Resources

ECONOMIC ASPECTS

APPENDIX to BULLETIN No. 76

DELTA WATER FACILITIES

Preliminary Edition

DECEMBER 1961

EDMUND G. BROWN
Governor
State of California

WILLIAM E. WARNE
Administrator
The Resources Agency of California
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STATEMENT OF CLARIFICATION

This preliminary edition presents a comparison of alter-
native solutions to the Delta problems. This bulletin shows that
the Single Purpose Delta Water Project is the essential min-
imum project for successful operation of the State Water Facili-
ties. This bulletin also presents, for local consideration, optional
modifications of the Single Purpose Delta Water Project which
would provide additional local benefits.

The evaluation of project accomplishments, benefit-cost
ratios, and costs of project services, are intended only to in-
dicate the relative merits of these solutions and should not be
considered in terms of absolute values. Benefits related to
recreation are evaluated for comparative purposes. Detailed
recreation studies, presently in progress, will indicate specific
recreation benefits.

Subsequent to local review and public hearings on this
preliminary edition, a final edition will be prepared setting
forth an adopted plan. The adopted plan will include, in addi-
tion to the essential minimum facilities, those justifiable optional
modifications requested by local entities.

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FOREWORD

This appendix to Bulletin No. 76, "Delta Water Facilities", discusses the economic aspects of the various plans which have been proposed as solutions to the water problems of the Delta area of California. Correlative and subsidiary information is included in order to convey a well-rounded picture to the reader. Methods of analysis generally follow those of standard works on the subject.

Data and analyses contained in this appendix were gathered prior to the publication of Bulletin No. 76, and were used as a partial basis for the recommendations therein. While the Single Purpose Delta Water Project is the minimum project which would provide for successful operation of the State Water Facilities, it is not the solution that would develop maximum net benefits. The economic aspects of optional modifications are, therefore, discussed in some detail. It is intended that these will form a factual basis for discussions by local interests.

It is important to note that <u>all</u> benefit-cost ratios, evaluations of project accomplishments, and costs of project services, are relative and <u>not</u> absolute. They are intended to provide a method of comparing the relative merits of the projects, without regard to actual dollar values. Necessarily, dollars are used throughout as units of worth, value, and cost. Benefits, which are reduced insofar as possible to dollar units, are based on the best information and projections presently available. Detailed recreation studies, now in progress, will probably change these estimates to some extent. It is believed, however, that the rank order of the various recreation benefits will not be significantly altered by the completion of the detailed studies.

Following local review and public hearings on Bulletin No. 76, a final report will be issued, which will incorporate comments and suggestions pertinent to the appendixes as well as the summary report. The final report will describe the essential minimum facilities, and those economically justifiable options requested by local interests.

CHAPTER I. INTRODUCTION

This appendix describes the engineering and economic studies relating to development of plans for a system of works in the Sacramento-San Joaquin Delta which will form an integral feature of the State Water Resources Development System. The economic aspects of salinity control, water supply, flood and seepage control, vehicular transportation, and recreation relating to a multipurpose Delta water facility are considered for four alternative plans. The findings presented herein are the result of intensive studies conducted over a five-year period from 1955 to 1960. Previous studies and cooperative investigations by various public and private agencies and individuals were utilized in the development of the comparisons.

Previous Reports and Legislation

Salinity incursion, flood damage, and related problems have long been a problem in the Delta. Early investigators were quick to recognize the uniqueness of the area and the complexity of the problems. The findings of these early studies and the history of the legislation pertaining to the Delta area define the basic policy under which this investigation has been conducted.

Salinity incursion into the Delta, which was recorded in 1841 and 1871, was recognized by early settlers as a potential problem of water supply, and a salt-water barrier was proposed in the

1860's. State Engineer Wm. Ham Hall subsequently studied a barrier to provide for flood control, and concluded that while a physical barrier could be constructed, the costs would exceed the benefits.

A series of subnormal water supply years began in 1917, which led to various proposals for barriers, advanced during the early 1920's. In cooperation with the State of California, the Sacramento Valley Development Association, and the U. S. Bureau of Reclamation, under the direction of Walker Young, extensively investigated four alternative barrier sites and concluded that it was "... physically feasible to construct a salt water barrier at any of the sites investigated." It was recognized that without a barrier, "... salinity conditions will become more acute unless mountain storage is provided to be released during periods of low river discharge." Economic analyses of proposed barriers were not made by Mr. Young.

Following investigation of the physical feasibility of barriers the State Division of Water Resources studied the problem of salinity incursion and the economics of barriers. Bulletin No. 27, "Variation and Control of Salinity in Sacramento-San Joaquin Delta and Upper San Francisco Bay", concluded that "... invasion of salinity as far as the lower end of the ... Delta is a natural phenomenon which, in varying degree, has occurred each year as far back as historical record reveals." It was also concluded that the Delta could be protected from saline invasion and be assured of ample and dependable water supplies if mountain storage was utilized to provide a controlled rate of outflow from the Delta.

Bulletin No. 28, "Economic Aspects of a Salt Water Barrier", concluded that it was not economically justifiable to construct a barrier. With conditions of upstream use at that time, it was concluded that the most economical solution to salinity incursion and provision of adequate water supplies in the Delta could be achieved by constructing upstream storage and providing controlled rates of outflow when the natural outflow was insufficient.

Abshire-Kelly Salinity Control Barrier Act of 1953

Shasta Reservoir, on the Sacramento River, was constructed and began operation in 1944 for salinity control of the Delta and other purposes. Expanding water requirements in the Central Valley and San Francisco Bay area stimulated reconsideration of barrier plans for water conservation and related purposes. Seven alternative plans for barriers in the Bay and Delta system were investigated by a Board of Consultants, and the State Division of Water Resources for the California Water Project Authority. The Board of Consultants concluded that barriers in the San Francisco Bay system would not be engineeringly feasible due to the uncertainty of the quality of water in a barrier pool. It was recommended by the Division of Water Resources that "... further consideration be given only to ... barriers ... at or upstream from the Chipps Island site" at the outlet of the Delta.

Abshire-Kelly Salinity Control Barrier Act of 1955

The Abshire-Kelly Salinity Control Barrier Act of 1955, incorporated as Chapter 1434 of the California Water Code, called for a study of a system of works in the Delta, referred to as the Junction

Point Barrier Plan, and the Chipps Island Barrier Plan. Principal purposes of these studies included development of complete plans for water supply in the San Francisco Bay area which would provide salinity control and urgently needed flood protection in the Delta.

A four-year investigation was contemplated and an interim report, Bulletin No. 60, "Salinity Control Barrier Investigation", was published in March 1957 by the Department of Water Resources. This report outlined a water plan for the San Francisco Bay area and recommended that the North Bay Aqueduct be authorized. The North Bay Aqueduct was authorized by the Legislature in 1957. The report also compared the Biemond Plan (a system of works in the Delta) with the Chipps Island Barrier Plan, and recommended that further study be limited to the Biemond Plan.

Abshire-Kelly Salinity Control Barrier Act of 1957

The Abshire-Kelly Salinity Control Barrier Act of 1957 was incorporated in the California Water Code as Chapter 2092. The chapter limited further Delta study to the Biemond Plan and stressed the need for improving the quality of water in the Delta, and making the most beneficial use of the water resources of the State. A report on these further studies was scheduled for release by March 30, 1959.

Legislation of 1959

The potential expansion of water requirements of the urban and industrial complex in the western Delta area, and the greater upstream water use with resultant depletion of outflow from the Delta, indicated need for more concentrated study of the water requirements and supplies of the Delta. Legislation was enacted in 1959 to undertake studies of the type and extent of future water requirements of lands which can be served from present channels in the western Delta, effects of upstream water uses on Delta supplies, plans for water service and costs thereof, and economic and financial feasibility of the plans. This legislation was incorporated as Chapter 1765 in the California Water Code to authorize studies of the most economical and efficient procedures of constructing levees for flood control.

Intensive studies were made of the future economic growth of lands which could be served from channels in the western Delta. Particular attention was given to the future municipal and industrial water needs in the area and the future water supplies available in the Delta. The studies were published as Bulletin No. 76, dated December 1960.

The unique character of the water supply problems of the Delta was recognized by the State Legislature in 1959, when it amended the California Water Code, by inclusion of Chapter 1766, to include "special general" policy regarding the Delta. This legislation calls for provision of salinity control and adequate water supplies in the Delta, and states that water should not be diverted from the Delta to which the users within the Delta are entitled. The policy in this act is basic to the planning and operation of all works in the Delta or diversions therefrom.

This legislation also described the area of the Delta to which the general policy applies. The boundary of the Delta, as described in Section 12220 of the Water Code, is indicated on Plate 1. The area considered in the intensive studies of water requirements and supplies is described as the western Delta study area.

Purpose and Scope of Investigation

The many studies of all the complex water-associated problems relating to the Delta were summarized in Bulletin No. 76. Bulletin No. 76 pointed out that there are several physically feasible methods of solving the water supply and related problems in the Sacramento-San Joaquin Delta and the upper San Francisco Bay system. This bulletin was prepared to summarize and evaluate the economic aspects and to present the methods of formulation of the most economical Delta facilities. Since the policy of providing local benefits at local option, wherever possible, has been incorporated in the project designs, this report presents a county-by-county analysis, and where necessary, beneficiary-by-beneficiary, to enable exercise of local option.

Comparison of Plans

Four plans are analyzed and compared in this appendix report. These plans are the most favorable of the many solutions which have been proposed. Each of the four alternatives presented has been discussed in detail in the summary report of Bulletin No. 76, and the other five office reports are outlined in the Foreword. These plans are:

1. Chipps Island Barrier Project
2. Single Purpose Delta Water Project
3. Typical Alternative Delta Water Project
4. Comprehensive Delta Water Project

The Chipps Island Barrier Project would incorporate a physical structure to exclude the ocean waters from the channels of the Delta, as shown on Plate 2, "Chipps Island Barrier Project". This structure would be located across the Sacramento River approximately 1 mile below Pittsburg. Appurtenant features, such as navigation locks, waste disposal features, Suisun Bay levee works, and an emergency navigation access, would be necessary to make the plan operative. The plan would provide a water supply of suitable quantity and quality. These benefits would be realized by export users of water from the Delta and local Delta water users.

The Single Purpose Delta Water Project, as shown on Plate 3, "Single Purpose Delta Water Project", would incorporate physical barriers and control structures on several Delta channels to control and direct the flow of water within the Delta. Salinity incursion would continue to be repelled by stream flow but the extent of incursion would be allowed to reach points above the confluence of the Sacramento and San Joaquin Rivers during periods of minimum controlled outflow from the Delta. The areas of local land thus deprived of a firm water supply, or those lands which would have their present supply further reduced, would receive a substitute supply via a separate conduit system in which the quality would be independent of the degree of salinity incursion. This project would provide the same beneficial water supply as would the Chipps Island Project.

The Typical Alternative Delta Water Project shown on Plate 4, "Typical Alternative Delta Water Project", would utilize the same concept of operation as the Single Purpose Delta Water Project to provide benefits to the functions of water supply. Master levees would also be incorporated to provide for flood and seepage control, vehicular transportation, and recreation. The extent of master levees incorporated in this alternative would depend upon requests for levees and commitment for the repayment of allocated reimbursable costs by the local people.

The Comprehensive Delta Water Project as shown on Plate 5, "Comprehensive Delta Water Project", would provide a master levee system for the entire Delta. Water supply benefits would be similar to the Single Purpose Delta Water Project.

Evaluation of Benefits and Detriments

Tangible primary benefits and detriments (those reducible to monetary values) of each plan have been evaluated. There are also intangible effects, which are not amenable to monetary evaluation, that have been analyzed as to possible effects and are discussed in this report. Benefits considered were restricted to net values which would accrue to the primary or initial recipient of project services--these are termed primary benefits. The project would undoubtedly have extensive secondary effects which would extend beyond the initial user of project services. These secondary benefits and detriments have not been considered in the economic evaluation of the Delta facilities.

Summary of Project Costs

Cost estimates for each of the alternative plans have been made on the basis of costs prevailing in January 1960. These cost estimates include: (1) a schedule of capital expenditures, (2) operation and maintenance costs; and (3) schedules of depreciation and obsolescence. Staging of the project features to accommodate local and export requirements is included in each of these estimates. Detailed cost estimates are included in the appendix to Bulletin No. 76, "Plans, Designs, and Cost Estimates".

Development of Benefit-Cost Ratios and Project Formulation

Benefit-cost ratios for each alternative plan have been computed. In addition, incremental benefit-cost ratios for each purpose of any one plan have been developed to formulate a plan which maximizes the net benefits. All benefits, detriments, and costs were scheduled as they would occur in time and then reduced to present worth, (1960). It should be noted that these benefit-cost ratios are comparative measures of the alternative projects and are inappropriate when considered independently because the projects are an integral segment of the overall State Water Resources Development System.

Allocation of Project Costs

A schedule of capital and annual costs has been allocated to each prime function for each alternative. Suballocations have been made to each beneficiary. The separable costs-remaining benefit method of allocation has been incorporated, in keeping with contracting principles established by the Department of Water Resources. Suballocations have been made in keeping with precedents. In the absence of an applicable precedent, the logic and assumptions basic to the allocations are included in this report.

Repayment Analysis

Schedules of repayment of each of the reimbursable costs have been itemized by beneficiary. Investment requirements for capital costs and annual operating costs have been compared for each of the alternatives. Detailed analyses of fund sources and bonding requirements have not been made for this unit of the State Water Facilities since this is more properly handled as an integral portion of the overall system. For this reason, the final price of project services may differ from the costs shown herein. However, the costs represent the uniform annual equivalent cost which must be obtained to repay reimbursable costs.

CHAPTER II. EVALUATION OF BENEFITS AND DETRIMENTS

Studies of the various Delta water facilities that were considered disclosed that both beneficial and detrimental effects would accrue. All four plans would provide water supply benefits pertaining to: (1) salvage of water otherwise required for salinity repulsion, (2) improvement of water quality to the western Delta through water service independent of channel quality, and (3) provision of supplemental supply to the western Delta area. Two of the plans would provide: (1) flood and seepage control benefits, (2) vehicular transportation benefits, and (3) recreation. All four of the plans would be detrimental to: (1) fish and game (2) navigation, (3) recreation, and (4) water quality.

Benefits and detriments from most of the above items would increase with the passage of time and at different rates. The variable benefits and detriments during the study period 1960-2020 were converted to equal annual equivalent values using an interest rate of 4 percent per annum.

Water Salvage

One of the principle objectives of the State Water Resources Development System is to conserve water in areas of surplus in Northern California for subsequent transport to areas of deficiency. The Delta plays an important part in achieving this objective since it receives all of the surplus flows of Central Valley rivers which drain to the ocean during winter and spring months and is the last location where water not needed in the areas of surplus can conveniently be controlled and diverted to beneficial use. Surplus water from the northern portion of the Central Valley and north coastal rivers will be conveyed by the natural river system to the

Delta where it must be transferred through Delta channels to export pumping plants without undue loss or deterioration in quality. Aqueducts will convey the water from the Delta to off-stream storage and use in areas of deficiency to the south and west.

Full demands on the State Water Facilities can be met until about 1981 from surplus water in the Delta with regulation by the proposed Oroville and San Luis Reservoirs. However, upstream depletions will reduce the available surplus supplies and water will have to be imported from north coastal sources after that year. It is anticipated that coordinated operation of the State Water Facilities and the Federal Central Valley Project will afford a limited increase in usable surplus Delta supplies beginning in 1981. Upstream depletions will continue to decrease the available surplus supplies of the Central Valley throughout the analysis period.

The coordinated use of surplus water in the Delta and of regulated or imported supplements to this supply, as required, is referred to as the Delta Pooling Concept. Under this concept of operation, the State will insure a continued supply of water adequate in quantity and quality to meet the needs of both the Delta service areas of the State Water Facilities and the export water users. Advantage will be taken of surplus water available in the Delta; and as the demand for water increases and the available surplus supply is reduced by further upstream uses, the State will assume the responsibility of guaranteeing a firm supply of water which will be accomplished by the construction of additional storage facilities and import works.

<u>Summary of Project Effects</u>

During winter months of most years flood flows exceed Delta uses and the excess waters flush ocean salts from the channel system. Surplus water can be diverted from the Delta under these conditions. During summer and early fall months the inflow to the Delta is, for the most part, limited to regulated flow of the Sacramento River. This supply must meet all uses in the Delta, and export therefrom, and prevent salinity incursion into the complex channel system. The amount of outflow from the Delta necessary to maintain a given water quality at the export pumping plants increases as the rates of export increase.

Water in the Sacramento River follows two basic routes to the export pumping plants: (1) from the vicinity of Walnut Grove through several generally parallel channels in a southerly direction across the central portion of the Delta, and (2) through channels in the western portion around Sherman Island, and then upstream into the central area. The quantities transferred by the first route are not sufficient to supply both the export pumps and the Delta users during summer months. Water transferred around Sherman Island by the second route is mixed with and carries ocean salts into the Delta. Therefore, greater quantities of water will be necessary to reduce the salinity concentrations in the western Delta, unless either a physical barrier is constructed or more water can be diverted directly across the central portion of the Delta. The four plans would salvage water by reducing the outflow requirements for water transfer and Delta use. Table 1 presents a summary of the outflow requirements during periods of low flow with each of the plans and with the present channel system. Since this period of low flow would exist only during relatively short periods of time (initially) and increase with the passage of time, and increased upstream depletion and export requirements, operation studies were necessary to evaluate the salvage of usable or stored water with each plan. Table 2 presents a summary of these studies.

TABLE 1

Summary of Outflow Requirements
During Periods of Low Flow
in Second-feet

	Years	With No Project	With Chipps Island Barrier Project	With Delta Water Project
Outflow Criteria		Export & diversion quality protection	Evapo-trans. fishway release and lockage losses	Salinity repulsion from Cross Delta canal
Operation	1960	1640	550	1000
	1980	4780	985	1000
	2000	5870	1420	1000
	2020	5940	1850	1000
Uncontrolled Delta Outflow	1960	680	290	525
	1980	1520	360	370
	2000	1230	360	260
	2020	830	370	210
Required Supplemental Release	1960	960	260	475
	1980	3260	625	630
	2000	4640	1060	740
	2020	5110	1480	790

TABLE 2

Summary of Outflow Requirements
(Thousands of Acre Feet Per Year)

	Year	With No Project	With Chipps Island Barrier Project	With Delta Water Project
Outflow Criteria		Export & diversion quality protection	Evapo-Trans. fishway release and lockage losses	Salinity repulsion from Cross Delta Canal
Operational Releases	1960	1200	400	750
	1980	3450	700	750
	2000	4250	1050	750
	2020	4300	1350	750
Uncontrolled Delta Outflow	1960	500	200	400
	1980	1100	250	300
	2000	900	250	200
	2020	600	250	150
Required Supplemental Release	1960	700	200	350
	1980	2350	450	450
	2000	3350	800	550
	2020	3700	1100	600
Water Salvaged	1960	0	500	350
	1980	0	1900	1900
	2000	0	2550	2800
	2020	0	2600	3100

Evaluation of Benefit

A basis of evaluation of the benefit of water salvage was selected which would reflect the incremental cost of water in the Delta to the export user. This method was selected in keeping with the Delta Pooling Concept and the established pricing and allocation procedures of the Department of Water Resources. Both the staging of future projects and the unit price for water in the Delta would vary with alternative Delta water facilities. This variation is due to the effective loss of yield because of different outflow requirements with alternative plans. Table 3 presents the estimated staging dates for facilities which would be required to meet the projected demand for water from the Delta with the alternative plans.

TABLE 3

STAGING OF THE UNITS OF THE CALIFORNIA WATER RESOURCES DEVELOPMENT SYSTEM WITH ALTERNATIVE DELTA WATER FACILITIES

Water Development Project	Existing Channel System	Chipps Island Barrier Project	Delta Water Project Alternatives
San Luis Reservoir	1968	1968	1968
Oroville Reservoir	1968	1968	1968
Delta Water Facility		1968	1968
Middle Fork of the Eel River	1976	1981	1981
First Stage, Trinity	1981	1988	1988
Second Stage, Trinity	1983	1990	1990
Mad-Van Duzen	1987	1994	1995
First Stage, Klamath	1989	1996	1997
Additional Projects	1995	2012	2020

Since the net salable yield of each project would vary, depending upon outflow requirements for Delta transfer, the Delta Pool Price would also vary. The reduction of the Delta Pool price made possible by each alternative, exclusive of Delta facility costs, is shown in Table 4.

TABLE 4

Reductions in the Delta Water Charge
Resulting from Alternative
Delta Water Facilities 1/
Equal Annual Equivalent Values 1960-2020

(Dollars per acre-foot)

Water Development Project	Chipps Island Barrier Project	Delta Water Project Alternatives
Oroville Reservoir, San Luis, and Delta Water Facility	1.25	1.25
Middle Fork, Eel	2.04	2.08
First Stage, Trinity	2.66	2.77
Second Stage, Trinity	3.89	4.02
Mad-Van Duzen	3.11	3.35
First Stage, Klamath	2.52	2.91

1/ By comparison with cost with existing channel conditions and exclusive of Delta facility cost.

The 1960 present worth value of the Delta water charges between 1960 and 2020 for each of the alternatives would be: (1) existing channel system, $522,011,000; (2) Chipps Island Barrier Project, $333,391,000; and (3) Delta Water Project (all variations), $319,222,000.

The 1960 present worth value of the water salvage benefit of the Delta Water Project (all variations) is $202,789,000, and the Chipps Island Barrier Project has a benefit of $188,620,000.

Water Quality in the Western Delta

Historically, salinity incursion in the Delta has created water supply problems. However with the construction and operation of Shasta Reservoir as a unit of the Federal Central Valley Project, this problem has been restricted to the western portion of the Delta. Plate 6, "Historical Salinity Incursion, Sacramento-San Joaquin Delta", illustrates the extent of historic incursion between 1920 and 1960. It may be noted that incursion of 1,000 parts per million chlorides to areas upstream from Chipps Island has taken place nearly every year.

The relatively poor water quality conditions which have prevailed historically, which have been even more pronounced in recent years within the western Delta channels, have resulted in severe water supply problems to municipal, industrial, and agricultural water users. Industries have suffered considerable expenses for water treatment equipment and chemicals. In addition, poor water quality has periodically caused production slowdowns, and in one instance, caused the shutdown of one plant for nearly a month. Municipal water supplies have frequently fallen below United States health standards in both chloride and total hardness concentrations. Agriculturists have suffered excessive leaching costs, lower incomes from reduced crop yields, and restriction to salt-tolerant crops which are in general lower income producers, and in some cases even physical loss of crops due to excessive salinity.

The causes of these poor water quality conditions include salinity incursion, agricultural drainage water from within the Delta itself, and the low quality of the seasonal runoff of the San Joaquin and adjacent rivers. These factors are particularly in evidence during periods of negligible precipitation.

In the future, the water quality conditions in the western Delta will continue to deteriorate without the construction of the State Water Facilities. This deterioration would be caused by increasing upstream consumptive use and the projected increases in water transfer across the Delta by the Central Valley Project of the U. S. Bureau of Reclamation. These factors would undoubtedly lead to increases in the intensity and duration of salinity incursion within the western Delta. Lessening of the detrimental effects of agricultural drainage water would occur since a higher dilution factor would be available with the greater transfer of water across the Delta. On the other hand, continued deterioration by the inflow of San Joaquin River water and San Joaquin Valley drainage, along with increased upstream pollution, might cancel the benefits of increased dilution of agricultural drainage water.

Effects of Alternative Delta Water Facilities

Each of the alternative Delta water facilities, constructed as an integral unit of the State Water Facilities, would provide water protected from deterioration due to salinity incursion to the Contra Costa County Water District, East Contra Costa Irrigation District, and Byron-Bethany Irrigation District. In addition, each of the alternatives would provide for improved agricultural drainage environment and routing of San Joaquin River waters. This combined with the high dilution factors associated with the transport of State and Central Valley Project water would lead to improved water quality within Old River.

To measure the degree of the water quality improvement which would result from construction of the State Water Facilities, estimates were made by months of the future average water qualities which would exist under project and nonproject conditions. The estimates of water qualities which would exist under nonproject conditions were based upon historical data contained whithin the yearly operation reports of the U. S. Bureau of Reclamation. These data include recorder charts of total dissolved solids and chloride ions at pumping plant No. 1 of the Contra Costa Canal, and monthly drop sample analyses of bicarborate, sodium, calcium, magnesium, and sulfate ion concentrations. The year 1959 was selected as the base year for assessing future average monthly conditions. Although the base year probably reflects water quality conditions which were somewhat poorer than average conditions, it was concluded that the base year selected would represent probable future average conditions.

Future water quality conditions under project conditions were based upon salt-routing studies conducted during 1958. These studies were verified during 1960 by means of more detailed analyses. Details of the methods used in the salt-routing studies are discussed in the appendix to Bulletin No. 76, "Salinity Incursion and Water Resources". Estimates of average monthly concentrations of salts under project and nonproject conditions are contained in Table 5.

Industrial and Municipal Water Quality Benefits

The unit industrial water benefits accruing from improvements in water quality were determined on the basis of savings in chemical costs and capital investment for water softening and demineralization processes. Savings in chemical costs were estimated by comparing the costs of treating water under project and nonproject conditions. Criteria for evaluating these costs were obtained from the published data of several manufacturers of water treatment equipment. Chemical costs were based on data obtained from chemical manufacturers and are shown in Table 6.

Costs and cost savings are shown in Table 7.

The savings in capital investment for water treatment equipment were estimated from the difference in investment necessary for equipment required under project and nonproject conditions. For water-softening equipment, these savings were based upon data of equipment manufacturers. Because of the many design considerations connected with demineralization equipment,

TABLE 5

Average Monthly Salt Concentrations in Old River
Under Project and Nonproject Condition

(Concentrations in parts per million)

Month	Nonproject Conditions 1/						Project Conditions					
	TDS	Cl	HCO_3	Na 2/	SO_4	Total Hardness	TDS	Cl	HCO_3	Na 2/	SO_4	Total Hardness
January	440	113	82	165	111	179	228	46	48	72	23	119
February	520	138	106	193	119	214	216	45	41	72	23	106
March	435	118	87	161	96	185	177	31	54	48	17	81
April	245	62	70	67	48	104	143	25	41	39	11	84
May	205	48	68	63	37	71	159	30	35	48	16	87
June	236	50	80	72	40	99	138	23	39	37	13	74
July	520	214	85	268	52	143	104	13	41	22	9	55
August	550	225	78	294	62	157	94	10	46	15	8	54
September	350	102	88	152	53	116	114	14	46	24	9	68
October	270	59	94	96	40	102	147	20	56	33	11	81
November	280	59	101	91	44	108	182	29	63	46	14	94
December	340	79	109	109	56	144	255	53	50	83	26	131

1/ Based on 1959 values.
2/ $CaCO_3$ Eq.

TABLE 6

Chemical Costs Used in Evaluating
Benefits in Water Treatment Costs

Chemical	Unit	Cost 1/
Salt	ton	$13.70
Sulfuric acid (66° Be)	ton	24.75
Caustic Soda (76 percent solution)	ton	56.00
Soda ash	ton	31.00

1/ Delivered at Pittsburg, California.

TABLE 7

Water Treatment Costs and Savings with State Water Facilities

(Cents per thousand gallons of treated water)

Month	Cost without State Water Facilities		Cost with State Water Facilities		Savings with State Water Facilities	
	Demineralization	Softening	Demineralization	Softening	Demineralization	Softening
January	30.71	2.64	13.09	1.59	17.62	1.05
February	36.21	3.22	12.25	1.38	23.96	1.84
March	30.34	2.72	10.35	0.99	19.99	1.73
April	16.13	1.35	8.16	0.99	7.97	0.36
May	13.74	0.83	9.10	1.06	4.64	-0.23
June	12.47	1.28	7.68	0.83	4.79	0.45
July	39.80	2.16	5.92	0.53	33.98	1.63
August	42.64	2.48	5.56	0.47	37.08	2.01
September	25.79	1.64	7.00	0.73	18.79	0.91
October	18.25	1.36	8.39	0.94	9.86	0.42
November	18.86	1.44	10.29	1.16	8.57	0.38
December	22.61	2.02	14.58	1.78	8.03	0.24
AVERAGE					16.27	0.90

the comparison of capital investment was beyond the scope of these studies. However, review of capital costs of several demineralizing plants indicate that a project savings at least equal to the cost of a softening plant would be realized. Therefore, the savings on demineralizing equipment were computed on this basis. Estimated capital savings are indicated in Table 8.

TABLE 8

Capital Investment in
Water-Softening and
Demineralization Equipment

(Dollars per thousand gpm capacity)

Without State Water Facilities	With State Water Facilities	Savings
$104,115	$86,653	$17,642

The annual benefits accruing from savings in chemical costs to industrial water users were estimated by multiplying the average savings per thousand gallons of treated water by the projected annual quantities of treated water. These quantities were determined on the basis of data obtained during a 1960 industrial water use survey (Appendix II, Delta Water Requirements, Bulletin 76, Delta Water Facilities) from which the percentages of the total water consumption which were softened or demineralized were determined. These percentages were assumed would remain constant through the 1960-2020 study period. These percentages were then applied to the projected future industrial water requirements of lands served from Old River, including the entire Contra Costa Water District, East Contra Costa Irrigation District, and Byron-Bethany Irrigation District. To compensate for the fact that several industries located on the north shore of Contra Costa County seasonally divert from the main river channels, future diversions were estimated for river quality conditions proposed by operation of the State Water Facilities. Water treatment chemical benefits were not claimed for these diversions.

Savings in capital investment were estimated on the basis of all new water treatment capacity added after 1968, the replacement of existing capacity in 1980, and the replacement of capacity added between 1960 and 1968 in 2000. These savings were converted to an annual basis by assuming that the annual costs, which include interest, operation and maintenance, taxes, insurance, replacement, and return on investment would amount to 15 percent of the capital investment.

Table 9 summarized the annual benefits accruing from savings in chemicals and capital investment.

TABLE 9

Annual Benefits Based on
Industrial Water Treatment Costs

(Dollars per year)

Item	1968	1980	2000	2020
Chemicals	288,600	569,400	1,222,100	2,007,900
Capital Investment	0	33,390	86,630	119,770

The 1960 present worth of the above benefits amount to $13,877,000. Municipal benefits were considered intangible since a great deal of the evaluation would depend on the habits of individual consumers. However, it is important to realize that the savings which will result by the halving of water hardness with the population growth foreseen in Contra Costa County could easily amount to several hundred thousand dollars per year.

Agricultural Water Quality Benefits

The benefits due to improvement of the quality of agricultural water as a result of the construction and operation of replacement water facilities in the lowland areas of the western Delta were evaluated on the basis of increases in agricultural net incomes. These increases in income will depend upon three economic advantages resulting from the guaranteed availability of high-quality water. These are: (1) changes in crop patterns from salt-tolerant-type crops to higher income crops, (2) increases in crop yields, and (3) reduction in leaching costs. The physical factors which lead to each of these advantages are contained in the companion report, "Delta Water Requirements".

The magnitude of net income increases has been evaluated as the improvement in the quality of water available under project conditions, compared to the quality of water available for irrigation within the Delta channels under nonproject conditions. Under nonproject conditions, these water qualities would depend upon the location of the specific diversion point. Therefore, the affected area was subdivided into several zones located by the river mileage along the Sacramento River from Golden Gate. These zones and the respective mileage are defined on Plate 7, "Agricultural Water Quality Zones Within the Western Delta". The area of agricultural lands within each zone is summarized in Table 10.

TABLE 10

Area of Agricultural Water Quality
Zones within the Western Delta

River-Mile Zone	Area of Agricultural Lands in Acres
52.5 - 55.0	1,500
55.0 - 57.5	5,000
57.5 - 60.0	5,500
60.0 - 62.5	9,000
62.5 - 65.0	15,500

Determination of applied irrigation water for each agricultural zone was based on the following criteria:

1. The maximum annual salinity incursion concentration would not exceed toxic limits during the maximum month of diversion at any specific point of diversion.

2. The weighted mean monthly salinity of the diverted water would be based upon the average monthly outflow for the 20-year water supply period (1922-1941), and derived from the salinity-outflow relationships developed in comparison, Appendix I, "Salinity Incursion and Water Resources", Bulletin No. 76.

3. The salinity of the diverted water would be adjusted to reflect the daily variation in salinity coinciding with variations in tidal stage 1/.

4. The quantity of water diverted each month would be proportional to the irrigation demand schedule.

5. Each point of diversion or area of diversion would be evaluated by salinity-zone grouping.

6. The future Delta outflow was based upon a minimum release of 1,500 cubic feet per second and continued upstream depletions without state exports.

7. The relationship of salinity concentrations at all locations was assumed to be the same as that which presently exists throughout the Delta. This relationship is discussed in the office report on "Salinity Incursion and Water Supply". The resulting average salinities of applied irrigation water for each agricultural zone are shown in Table 11.

1/ "Variation and Control of Salinity", Bulletin No. 27, Department of Water Resources, 1931.

TABLE 11

Salinity of Irrigation Water
Available from Existing Channel System Under
Present and Future Conditions of
Upstream Consumptive Use

River-Mile Zone 1/	Area of Agricultural Land (in acres) 2/	Salinity of Available Water (in parts per Million Chlorides)			
		1960	1980	2000	2020
52.5 - 55.0	1,500	1,000	1,350	1,540	1,590
55.0 - 57.5	5,000	750	970	1,040	1,090
57.5 - 60.0	5,500	330	450	510	550
60.0 - 62.5	9,000	120	170	200	230
62.5 - 65.0	15,500	60	100	120	130

1/ Miles from Golden Gate.

2/ Approximately 3,000 additional acres may be subjected to salinity varying from 100 to 5,000 parts per million chlorides. Portions of these lands may not be actively irrigated, and on others the influence of 100 ppm chlorides on water cannot be clearly defined.

The determination of the economic benefit was based upon computation of the net farm income for the salinity conditions listed in Table 11 and the nonsaline conditions which will be provided by the project. Incomes for both existing crop patterns and projected future crop patterns were made for non-saline conditions.

The estimate of net income was based upon the relationship of yield and salinity of applied water as developed in the companion report "Delta Water Requirements". This relationship was developed into operators' income as shown on Plate 8, "The Economic Effects of Reduced Crop Yields on Farm Operator Income in the Sacramento-San Joaquin Delta". Data for this plate was taken from the 1952-56 average price for farm production costs and crop returns.

Leaching costs were also adjusted upon a basis varying with the severity of the salinity of irrigation water. The maximum annual leaching cost was set at $7 per acre per year.

The results of the above analysis are indicated on Plate 9, "Net Agricultural Income Under Saline and Nonsaline Conditions in the Western Delta". The area between the curves for income with existing crop patterns under saline conditions, and the income for projected crop pattern under nonsaline conditions was taken as the net benefit. The 1960 present-worth value of this benefit is $6,036,700. **Annual benefits are shown in Table 12.**

TABLE 12

Annual Benefits of Salinity Protection
to Agricultural Lands in the Western Delta

Year	Annual Benefit
	Thousand Dollars per Year
1960	278
1980	309
2000	320
2020	325

Western Delta Supplemental Water Supply

Within the western Delta there is an industrial complex of large magnitude. Projections of future growth indicate extensive future development may be expected. With the establishment of new industry and the expansion of existing facilities there will undoubtedly be large increases in population. As described in the Appendix to Bulletin 76, "Delta Water Requirements", this growth and the related need for water have been projected. To the extent that this water requirement exceeds the ability of existing and presently proposed local water supply facilities, it has been considered economical to provide excess capacity in the project substitute water supply facilities to meet these future supplemental requirements. The areas in which supplemental water supplies were specifically considered in the design of facilities were limited to those areas which would be affected by salinity incursion. The remaining areas, principally that area in Contra Costa County south of Rock Slough, could obtain a supply directly from the Delta channels with or without the Delta water facilities. Table 13 summarizes the water requirements for those areas within the western Delta which could be met with existing facilities or by diversions from Delta channels south of Rock Slough.

TABLE 13

Future Water Requirements of the Western Delta
Which Could be Met from Existing
Channels and Facilities

(Thousands of acre feet per year)

Year	Contra Costa Canal	Old River Diversions
1970	45,720	4,100
1980	55,900	7,900
1990	79,300	22,100
2000	99,200	46,100
2010	114,600	104,000
2020	126,800	172,900

The benefits of these supplemental supplies to the Contra Costa

County area can be most readily evaluated by comparison with the second lowest cost alternative source of supply of water with a quality of equal standards. The lowest cost alternative was used as an alternative cost in the cost allocation studies discussed in Chapter V. The potential sources considered were: (1) an expansion of the Contra Costa Canal through the Federal Central Valley Project; (2) purchase of a supply through the East Bay Municipal Utility District; or (3) local purchase of salinity control outflow and independent supply facilities from the river.

Expansion of the Contra Costa Canal potential was found to be the most economical and was utilized as an alternative cost. Purchase of a supply through the East Bay Municipal Utility District was found to be the second lowest cost alternative and was utilized as the benefit of supplemental water supply. A value of $20 per acre foot was placed upon this water for the purposes of computing the benefit.

Alternative supplemental supply to Delta areas in Solano County could be most cheaply accomplished by diversion out of the North Bay Aqueduct or a similar system. The second lowest cost alternative was assumed to cost the same as that of Contra Costa County, $20 per acre foot of water. This value was used in computation of the benefit of supplemental water supply to Solano County.

Table 14 presents the anticipated delivery schedules by decades for both areas. The 1960 present worth of the benefit of supplemental supply to Contra Costa County would be $26,482,000, and the benefit to Solano County would be $3,886,000.

TABLE 14

Schedule of Supplemental Water Deliveries
to Portions of Contra Costa and Solano Counties
Within the Western Delta

Year	Deliveries, in thousands of acre-feet per year	
	Contra Costa	Solano
1970	0	0
1980	58.7	0
1990	102.7	1.5
2000	150.4	18.0
2010	193.1	55.0
2020	232.2	130.1

Flood and Seepage Control Benefits

The fortunate combination of fertile soils, convenient water supplies, and shallow-draft shipping to Central California markets led to the development of an intensified agricultural economy in the Delta. Initial reclamation of the marshland began slowly after passage of the "Arkansas Act" in 1850. This activity was accelerated in 1861 by passage of the "Swampland Act" by the State Legislature. The reclamation started on the periphery and gradually worked into the heart of the deep peat areas in the center of the Delta area. Table 15 presents the accumulated acreages reclaimed by decade.

TABLE 15

PROGRESSIVE RECLAMATION IN THE DELTA 1/

Year	Acreage reclaimed	Permanent inundations	Accumulated acreage
1860-1870	15,000		15,000
1870-1880	73,000		88,000
1880-1890	70,000		158,000
1890-1900	58,000		216,000
1900-1910	93,000		309,000
1910-1920	94,000		403,000
1920-1930	20,000	4,000 2/	419,000
1930-1940	0	3,000 3/	416,000
1940-1950	0		416,000
1950-1960	0		416,000

1/ The Delta as defined by the lowlands boundary.
2/ Lower Sherman and Big Break (Porter Estates).
3/ Franks Tract.

The first levees were constructed by coolie labor and by use of Fresno scrapers. The levees were modest in height and width, and usually were intended to give protection from only slightly higher than normal water stages. High stages would cause inundation; however, since reclamation costs were not great, a farmer could get back into business with a reasonable outlay of cost and effort. As the intensification of agriculture, and correspondingly, the required degree of flood protection increased, there was a constant search for more efficient methods of levee construction.

The Delta has suffered from many floods during the past 100 years. Most of the islands and tracts have been inundated at least once since reclamation and some have been flooded on several occasions. During the period 1900 through 1960, 467,000 acres of reclaimed land have been flooded in the Delta, not including inundation of lands located in the Yolo Bypass. The 467,000 acres flooded in the past 60 years are equal to the entire land area of the Delta lowlands. A summary of historical inundations is shown in Table 16.

TABLE 16

HISTORICAL INUNDATIONS IN THE DELTA[1/]

Year	Acres inundated	Year	Acres inundated
1900	12,900	1926	3,400
1901	20,800	1927	2,200
1902	14,700	1928	8,900
1904	75,900	1932	3,000
1906	63,100	1936	5,100
1907	114,700	1937	3,000
1908	12,400	1938	19,000
1909	43,500	1950	20,900
1911	9,200	1955	11,500
1925	11,800	1958	11,200

1/ Inundations occuring in the Yolo Bypass are not included in this table.

Reclamation Problems

The highly organic soils which make the Delta a rich agricultural area also present serious difficulties in the reclamation and operation of the land. Land subsidence, poor foundation conditions, and excessive seepage are paramount among these problems. Each of these problems was relatively minor at the time of original reclamation, but with the passage of time, they have grown in severity to a point where they are jeopardizing the continued economical operation of many acres of Delta land. These factors are significantly reflected in land values throughout the area, which are only a fraction of the reasonable worth of the products grown. Land having a net income potential in excess of $100 per acre per year is valued between $400 and $600 per acre. The ever-increasing reclamation costs, and the constant threat of floods are thus evidencing themselves in the economy of the area.

Land Subsidence. Early measurements by W. W. Weir and subsequent studies by F. E. Broadbent have attributed the principal source of land subsidence in the Delta to the surface layer of organic soils. Additional evidence of this fact is being borne out by area-wide level nets which have been established and are being periodically resurveyed by the U. S. Coast and Geodetic Survey under contract to the Department of Water Resources. Potential deep-seated subsidence caused by the extraction of natural gas from the Rio Vista and River Island gas fields has been investigated and appears to make up only a small portion of the historic subsidence. The deep peat areas of the Delta have been found to subside at an average rate of 1 foot every 4 years, complicating the problems of flood and seepage control. As the land surface gradually lowers with respect to the water surfaces of the channels surrounding the Delta islands, the rate of seepage into the islands increases. Because of this, the drainage costs in the Delta have steadily increased.

Foundation Conditions. Subsidence, coupled with the poor foundation conditions provided by the peat soils, has created problems in levee construction and maintenance peculiar to the Delta. The foundation conditions have limited the height of levees in some locations, preventing unlimited flood protection. Consolidation of the highly compressible organic soils has resulted in frequent and costly levee raising in order to maintain the desired degree of protection. Subsidence has contributed to levee instability by increasing the hydrostatic forces acting against the levees and the seepage forces acting beneath the levees.

The problems in constructing and maintaining a levee system on organic foundations are numerous. The peat soils of the Delta are unstable when loaded, both in respect to continuing consolidation over periods of years, and in respect to nonpredictable losses of shear strength under a variety of conditions. The increased stresses in the foundations, resulting from continued land subsidence, and the associated increase in levee height are causing a loss in flood protection. This effect on flood frequencies was analyzed with a series of stability analyses comparing soil stress in levees and foundations under conditions of anticipated subsidence. Plate 10, "Subsidence and its Relation to Levee Stability", summarizes the findings of this study.

Experimental levee studies authorized by Chapter 1765, California Statutes of 1959, are being conducted at various points within the Delta. These studies will increase present knowledge in the field of organic soil mechanics and will assist in the development of more economical levee standards.

Seepage Problems. The seepage problems within the Delta today are much more severe than they were when the islands were first reclaimed and conditions will worsen as subsidence of the organic soils continues. The rate of seepage inflow is dependent upon the permeability of the water-carrying strata and upon the difference in elevation between the channel water surface and the ground water surface within the islands.

The interiors of most of the Delta islands have areas which are at least 10 feet below sea level, with some areas 15 or more feet below sea level. Ground water surfaces are usually held 2 feet below the land surface and the mean tidal elevation of channels within the central Delta is approximately 1.5 feet above mean sea level. This results in a seepage-producing differential head of at least 13.5 feet, as shown on Plate 10.

In order to cultivate the land and maintain proper conditions for plant growth, the ground water surface must be maintained at least 1.5 feet below the ground surface. To accomplish this, a network of drainage ditches must be dug to collect the seepage water and deliver it to a pumping plant located just inside the levee. The pump or pumps lift the drainage water over the levee and discharge it into the adjacent channel. Some of the water removed is runoff from rainfall or excess irrigation water, but the major portion of the drainage costs can be attributed to seepage.

The hydrologic equation has been utilized to estimate the rates of seepage inflow for various Delta islands. The equation is given below:

$$S = O_s + ET - P - I_s \pm \Delta ST$$

S = the amount of seepage inflow or outflow

O_s = the surface outflow

ET = evaporation and transpiration losses

P = precipitation

I_s = surface inflow

ΔST = change in ground water storage

The Department of Water Resources has applied the hydrologic equation to 33 Delta islands and obtained seepage rates varying from 0.021 to 0.631 acre-feet per acre per month. The average seepage rate for the 33 islands was found to be 0.201 acre-feet per acre per month. Data were obtained for the equation during the period May 1954 through October 1955. Surface outflow was obtained by rating the drainage pumps to determine the relationship of power consumption to pump outflow. Precipitation was measured at Walnut Grove, Mandeville Island, and Tracy. The rainfall, as measured at Walnut Grove, was assumed to be effective over the northern Delta islands, while records from the Mandeville and Tracy stations were applied to the central and southern Delta, respectively. Evapotranspiration was calculated by using the unit consumptive use figures found in the Division of Water Resources publication, "Trial Water Distribution, 1955". The surface inflow into each island was computed by multiplying the applied water factor for each crop by the crop acreage. The applied water factor was obtained from Volume II of the "Report on 1956 Cooperative Study Program, Water Use and Water Rights Along Sacramento River and in Sacramento-San Joaquin Delta", published by the Department of Water Resources in March 1957. Changes in ground water storage were not measured. It was assumed that over a 12-month period there would be no net change in ground water storage.

A more detailed hydrologic study is presently being conducted on Twitchell Island in the Delta. Seepage is being determined by actual measurement of all the terms in the hydrologic equation, with the exception of evapotranspiration. The average rate of seepage during the first 7 months of the study was found to be 0.13 acre-feet per acre per month. This figure is approximately 12 percent lower than the 0.146 acre-foot per acre per month rate as determined for Twitchell Island by the 1954-55 study.

Continued subsidence of the Delta's organic soils will increase the rates of seepage into the islands. Darcy's law for the flow of water through a permeable media is $V = KS$; where V is the velocity of flow, S is the slope of the hydraulic gradient, and K is the coefficient of permeability. Lowering of an island's land surface will increase the slope of the hydraulic gradient, thereby increasing the flow of seepage water into the island. The effect of this increased seepage can be seen in the following example.

A typical Delta island may have a surface area of 5,000 acres, differential head of 20 feet between the channel water surface and the island ground water surface, and a present seepage rate of 0.2 acre-foot per acre per month. The present annual seepage inflow would be given by the following equation:

$$\text{Seepage} = \frac{0.2 \text{ acre-feet/acre}}{\text{month}} \times 5{,}000 \text{ acres} \times \frac{12 \text{ months}}{\text{year}} = 12{,}000 \text{ acre-feet/year.}$$

Since the soils of this island are organic and subsidence occurs at the rate of 1 foot every 4 years, the seepage-producing differential head will increase to 25 feet in the next 20 years. The seepage rate would then be $\frac{25}{20} \times \frac{0.2 \text{ acre-feet/acre}}{\text{month}}$ or $\frac{0.25 \text{ acre-feet/acre}}{\text{month}}$. Seepage inflow would then be 0.25 x 5,000 x 12 = 15,000 acre-feet per year.

The annual seepage into this island would continue to increase by 3,000 acre-feet each 20 years until subsidence has removed the organic soils and exposed the underlying mineral soils.

Land Use Patterns

Since a large portion of the lands within the Delta area is used for agricultural purposes, detailed studies of historic and present crop patterns have been made. Present and past crop patterns and information obtained from interviews with local growers and county farm advisors were used as the basis for predicting a representative crop pattern for the period of analysis.

The Comprehensive and Typical Alternative Delta Water Projects would provide flood protection by enclosing groups of islands within a system of master levees. In order to evaluate the flood control aspects, it was necessary to determine representative future crop patterns for each of six island-groups. The location of these groups is shown on Plate 11, "Location of Island-Groups". Table 17 shows the present crop patterns for each island-group. Table 18 presents the projected crop patterns. The crop patterns, as projected to 1990, were assumed to be representative of the analysis period 1960 to 2020. The present crop patterns are based on a 1955 land-use survey of the Delta, made by the Division of Water Resources. No significant change in crop patterns was noted when the 1955 survey was compared with a crop survey of the western Delta made in 1958 and 1959.

Crop incomes were computed for each crop. The analyses are based upon production costs, crop yields, prices received, and cultural practices data as of 1960 as determined from local agriculturalists and comparative conditions elsewhere in the State. Table 19 presents a summary of these studies.

Cost Per One Inundation

The damages resulting from one inundation can be classified into three groups: (1) crop damage due to flooding; (2) reclamation costs; and (3) nonagricultural damage (not evaluated in this study).

The magnitude of crop damages caused by flooding is dependent upon the crop being grown, the time of occurrence of the flood, and the duration of submergence.

A study of previous floods in the area revealed that approximately 64 percent of the inundations occurred during the period of October through February, with the remaining 36 percent occurring after March 1. The average duration of submergence is three months, with three weeks required for drying the land following dewatering.

TABLE 17

PRESENT CROP PATTERNS BY ISLAND-GROUP[1]

Crop	Isleton		Lodi		Holt		Tracy		Brentwood		Sherman		Total	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Alfalfa	1,308	3.1	1,207	2.3	8,009	8.9	2,262	25.1	1,137	4.6	274	2.9	14,197	6.2
Asparagus	3,371	7.9	13,773	26.6	40,087	44.3	2,581	28.7	9,349	37.7	---	---	69,161	30.3
Barley	8,915	20.8	7,624	14.7	11,169	12.3	986	11.0	2,983	12.0	3,733	39.3	35,410	15.5
Beans	66	0.2	56	0.1	---	---	---	---	---	---	---	---	122	0.1
Celery	24	0.1	880	1.7	170	0.2	---	---	---	---	---	---	1,074	0.5
Corn (grain)	8,330	19.5	3,800	7.4	5,696	6.3	391	4.3	1,012	4.1	976	10.3	20,205	8.9
Corn (silage)	3,332	7.8	1,520	2.9	2,278	2.5	158	1.7	405	1.6	390	4.1	8,083	3.5
Grain hay	3,821	8.9	3,267	6.3	4,787	5.3	422	4.7	1,279	5.2	1,600	16.8	15,176	6.6
Grapes	---	---	54	0.1	---	---	---	---	52	0.2	---	---	106	0.1
Milo	4,998	11.7	2,281	4.4	3,418	3.8	235	2.6	608	2.4	586	6.2	12,126	5.3
Miscellaneous	572	1.3	80	0.2	77	0.1	---	---	---	---	---	---	729	0.3
Onions	---	---	65	0.1	498	0.5	---	---	---	---	---	---	563	0.2
Pasture	748	1.7	7,650	14.8	823	0.9	90	1.0	7,224	29.1	270	2.8	16,805	7.4
Pears	722	1.7	102	0.2	70	0.1	---	---	88	0.4	---	---	982	0.4
Potatoes	774	1.8	3,263	6.3	4,110	4.5	---	---	---	---	---	---	8,147	3.6
Rice	---	---	1,272	2.5	72	0.1	---	---	---	---	---	---	1,344	0.6
Safflower and Sunflower	136	0.3	---	---	1,448	1.6	343	3.8	115	0.5	95	1.0	2,137	0.9
Sugar Beets	2,488	5.8	1,120	2.2	1,376	1.5	368	4.1	19	0.1	548	5.8	5,919	2.6
Tomatoes	3,155	7.4	3,721	7.2	6,382	7.1	1,166	13.0	521	2.1	1,026	10.8	15,971	7.0
TOTAL	42,760	100.0	51,735	100.0	90,470	100.0	9,002	100.0	24,792	100.0	9,498	100.0	228,257	100.0
Percent of Total		18.7		22.7		39.6		3.9		10.9		4.2		100.0

1/ Based on a 1955 crop survey of the Delta.

TABLE 18

CROP PATTERNS BY ISLAND-GROUPS, PROJECTED TO THE YEAR 1990

Crop	Isleton		Lodi		Holt		Tracy		Brentwood		Sherman		Total	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Alfalfa	1,283	3.0	1,552	3.0	12,665	14.0	2,972	33.0	1,240	5.0	95	1.0	19,807	8.7
Asparagus	1,710	4.0	7,760	15.0	9,047	10.0	1,260	14.0	3,719	15.0	---	---	23,496	10.3
Barley	8,552	20.0	7,243	14.0	13,570	15.0	900	10.0	3,719	15.0	3,894	41.0	37,878	16.5
Beans	85	0.2	52	0.1	---	---	---	---	---	---	---	---	137	0.1
Celery	---	---	879	1.7	181	0.2	---	---	---	---	---	---	1,060	0.5
Corn (grain)	8,979	21.0	5,174	10.0	9,047	10.0	360	4.0	1,735	7.0	949	10.0	26,244	11.5
Corn (silage)	4,276	10.0	2,121	4.1	4,524	5.0	180	2.0	744	3.0	380	4.0	12,225	5.4
Grain hay	3,421	8.0	3,621	7.0	7,238	8.0	450	5.0	1,735	7.0	1,805	19.0	18,270	8.0
Grapes	---	---	52	0.1	---	---	---	---	50	0.2	---	---	102	0.1
Onions	---	---	52	0.1	905	1.0	---	---	---	---	---	---	957	0.4
Milo	5,131	12.0	3,104	6.0	4,524	5.0	270	3.0	1,487	6.0	1,045	11.0	15,561	6.8
Miscellaneous	559	1.3	103	0.2	1,538	1.7	---	---	---	---	---	---	2,200	1.0
Pasture	1,283	3.0	8,795	17.0	1,809	2.0	180	2.0	7,438	30.0	380	4.0	19,885	8.7
Pears	727	1.7	103	0.2	90	0.1	---	---	99	0.4	---	---	1,019	0.4
Potatoes	427	1.0	1,552	3.0	4,524	5.0	---	---	---	---	---	---	6,503	2.8
Rice	---	---	1,293	2.5	---	---	---	---	---	---	---	---	1,293	0.6
Safflower and Sunflower	128	0.3	---	---	2,714	3.0	270	3.0	248	1.0	95	1.0	3,455	1.5
Sugar Beets	2,565	6.0	2,588	5.0	7,238	8.0	450	5.0	1,587	6.4	665	7.0	15,093	6.6
Tomatoes	3,634	8.5	5,691	11.0	10,856	12.0	1,710	19.0	991	4.0	190	2.0	23,072	10.1
TOTAL	42,760	100.0	51,735	100.0	90,470	100.0	9,002	100.0	24,792	100.0	9,498	100.0	228,257	100.0
Percent of Total		18.7		22.7		39.6		3.9		10.9		4.2		100.0

TABLE 19

FARM INCOME PER ACRE BY CROPS[1]

Crop	Units	Yields	Price	Gross income	Variable costs[2]	Fixed costs[3]	Net income[4]
Alfalfa hay	ton	6.0	25.00	150.00	48.20	79.50	22.30
Asparagus	cwt	23.0	12.00	276.00	119.00	110.10	46.90
Barley[5]	cwt	30.0	2.25	67.50	25.00	30.25	12.25
Corn (grain)	ton	2.5	60.00	150.00	60.20	65.75	24.05
Corn (silage)	ton	20.0	5.00	100.00	28.70	62.90	8.40
Grain hay[5]	ton	3.0	24.00	72.00	26.80	34.45	10.75
Irish potatoes	cwt	230.0	2.20	506.00	290.80	113.40	101.80
Irrigated pasture[6]	cwt	6.0	20.00	120.00	44.05	73.80	2.15
Milo	ton	2.0	60.00	120.00	40.70	66.80	12.50
Pears	ton	15.0	70.00	1,050.00	548.50	213.20	288.30
Sugar Beets	ton	21.0	11.50	241.50	121.85	85.25	34.40
Tomatoes (processing)	ton	18.0	22.50	405.00	252.75	98.35	53.90

1/ Principal crops; represent 96 percent of the crops grown in the study area. Basic data from crop budget work sheets. Prices and costs based on 1952-1956 base period.

2/ Includes hired labor, operators' wages, equipment and material costs, and a management charge.

3/ Includes 5 percent interest on capital, depreciation, taxes, drainage costs, general expenses, and other allowances.

4/ The residual to management after all costs have been paid.

5/ Grown in rotation and often in double-crop arrangements with other crops. Only one-half of the normal fixed costs is charged to these crops in this table.

6/ Pasture value converted into growth of beef cattle. Price refers to cwt beef produced. Fifteen Animal Unit Months, (AUM) carrying capacity produces 6 cwt beef.

The per acre flood damages due to one flood were determined for each of the 12 major Delta crops. Damages were computed for floods occurring at various times during the year, and then weighted according to the historical record of occurrence. It was assumed that if an island was inundated prior to March 1, the island could be dewatered and the land prepared for planting by July 1. A normal crop of corn, milo, or tomatoes can be obtained if planted prior to this date.

The submergence of perennial crops, such as asparagus and alfalfa, causes the loss of at least a portion of the stand. The percentage loss is dependent upon the duration of the submergence. Consequently, the flood damage to perennial crops is the sum of the damages incurred at the time of floods plus the losses due to reduced yields in subsequent years while a new stand is developing.

Table 20 shows the total per acre crop damage due to a single inundation for each of the 12 major crops.

TABLE 20

CROP DAMAGE PER ACRE[1/]
(One inundation)

Crops	Gross income per acre[2/]	Crop loss[3/] Variable costs	Crop loss[3/] Fixed costs	Stand damage: perennial crop[4/]	Net income loss[5/]	Crop salvage[6/]	Total loss	Net value of second crop[7/]	Net crop loss
Alfalfa	150.00	4.85	79.50	15.00	32.10	---	131.45	43.30	88.15
Asparagus	276.00	31.00	110.10	110.00	53.90	59.40	245.60	43.30	202.30
Barley	67.50	13.60	30.25	---	14.75	---	58.60	43.30	15.30
Corn (grain)	150.00	8.45	65.75	---	31.60	---	105.80	46.00	59.80
Corn (silage)	100.00	10.05	62.90	---	15.15	---	88.10	36.70	51.40
Grain hay	72.00	14.00	34.45	---	14.75	---	63.10	43.30	19.80
Irish potatoes	506.00	44.55	113.40	---	113.30	---	271.25	43.30	227.95
Milo	120.00	5.85	66.80	---	18.65	---	91.30	40.60	50.70
Pasture	120.00	7.00	61.85	10.00	5.65	24.40	60.10	43.30	16.80
Pears	1,050.00	152.10	213.20	138.60	300.35	---	1,708.65[8/]	---	1,708.65
Sugar beets	241.50	24.05	85.25	---	45.25	24.15	130.40	61.25	69.15
Tomatoes	405.00	11.00	98.35	---	70.05	---	179.40	43.30	136.10

1/ Based upon data from the payment capacity crop budget analyses for the crops grown in the area. Data adjusted for seasonal influence. Floods of record occurred as follows: 64 percent during October-February, inclusive; 36 percent, March-September, inclusive. Second crops possible following October-February floods. Average duration is 3 months, with 3 weeks required for land drying following dewatering.

2/ Data from Table 19.

3/ Weighted average variable costs incurred at time of flood. Fixed costs were charged as a loss to the initial crop. (See footnote 7.)

4/ Based upon weighted average inventory values at time of flood.

5/ Includes operators' wage losses during period of inundation, in addition to net incomes, as indicated in Table 19.

6/ A partial harvest of asparagus and sugar beets probable prior to late spring floods.

7/ Variable costs only charged to second crop. Following the October-February floods the second crops were presumed to be: grain corn, 20 percent; corn silage, 10 percent; milo, 60 percent; and sugar beets, 10 percent (except acreages initially planted in these crops which were assumed to be replanted to the same crops). Eighty percent of the acreage flooded during October-February was assumed to be replanted during the season.

8/ Damages to pear orchards are as follows: 20 percent stand loss in the October-February flood; and 50 percent stand loss in the March-September flood. Year of flood, $792.20 damage; $904.40, or $226.10 per year loss in income during the following 4-year period required to re-establish trees.

The total crop damage by island-group due to one flood is shown in Table 21. The damage was computed by summing the products of the per acre flood damages and the acreage for each crop.

TABLE 21

CROP DAMAGE BY ISLAND-GROUP
(One inundation)

Island-group	Acre	Damage
Isleton	42,760	3,775,700
Lodi	51,735	4,299,200
Holt	90,470	7,961,400
Tracy	9,002	876,800
Brentwood	24,792	1,730,500
Sherman	9,498	251,700
TOTALS	228,257	18,876,900

The reclamation cost is the sum of the expenditures required to place the island or tract in production following a flood. This includes the costs of closing the levee break, dewatering the island, repairing levee damage caused by wave wash, land leveling to correct soil erosion and deposition, and repairing the irrigation and drainage system.

Costs of reclaiming Delta islands flooded in the past were studied in order to determine the average per acre expenditure required to reclaim an inundated tract. The Delta floods of 1955, in particular, provided much information on reclamation methods and costs. Two hundred dollars per acre was determined to be a reasonable estimate of the expenditure required to return an island to agricultural production following a flood. The breakdown of this cost appears in Table 22.

TABLE 22

RECLAMATION COSTS PER ACRE

Item	Cost
Closures	$ 40
Dewatering	15
Levee wash	55
Soil erosion	12
Land leveling	40
Irrigation and drainage	20
Subtotal	$ 182
Contingencies, 10 percent	18
TOTAL	$ 200

Flood damages other than crop losses and reclamation costs have not been evaluated in this report. The unevaluated damages are those to utilities, buildings, farm equipment, and roads.

Comparison of Nonproject and Project Flood Damages

Project benefits due to reduced inundations have been evaluated by a comparison of projected flood damage costs with and without the project. Since each of the two projects have common island groups, this comparison has been compiled by island groups.

Nonproject Conditions. The present flood frequencies were furnished by the Sacramento District of the U. S. Corps of Engineers. The island flood frequencies are based on the frequency of river stages at three gaging stations within the Delta and on the elevations of the levee crowns. It is recognized that flood damages computed using flood frequencies determined by this method, are conservative. Inundation of land within the Delta protected by levees is usually due to structural failure of the levees rather than overtopping.

Continued subsidence will tend to reduce levee stability in the Delta. The reduced stability will cause an increase in inundation. For the purpose of evaluating future flood damages, the flood frequencies based on overtopping were modified to reflect decreasing levee stability by increasing the flood frequencies by the ratio of present to future stability factors.

Damages, benefits, and costs in this report are presented by island group. For this reason the present and predicted future flood frequencies of each island group were determined by calculating the weighted averages of the island flood frequencies. The average annual flood damage for each island group was determined for the years 1960, 1980, 2000, and 2020 by multiplying the damage due to one inundation by the island-group flood frequency. The average annual flood damages for nonproject conditions are shown in Table 23.

Project Conditions. One hundred three thousand acres, including 95,000 acres of crop land, are afforded flood protection by the Typical Alternative Delta Water Project. The Comprehensive Delta Water Project will protect 252,000 acres, 228,000 of which are crop lands.

The Typical Alternative or Comprehensive Delta Water Projects would provide flood protection by a master levee system which would divide the Delta islands into groups. A system of channel closures in the master levee system would exclude flood waters from the interior channels of the island groups. The master levees would be constructed to a height well above the anticipated flood stage and would furnish greatly improved protection against structural failures. The improvement in structural stability would be obtained by the construction of a berm on the landward side of the levee. This berm would act as a counterweight, resisting forces tending to produce movement along a circular arc or failure due to spreading. Studies of past levee failures have revealed that the circular or spreading failures are the most common type.

For the purpose of evaluating flood damages under project conditions, the flood frequency has been assumed to be one inundation in 1,000 years. Reduced stability due to subsidence has been accounted for by adjusting the flood frequency for future conditions. Plate 12, "Projected Average Annual Inundations", shows the average number of acres flooded per year at present and in the future, with and without the Typical Alternative and Comprehensive Delta Water Projects. The average annual damage due to inundation after construction of the Comprehensive or Typical Alternative Delta Water Projects is shown in Table 24.

TABLE 24

FLOOD DAMAGE BY ISLAND-GROUP DUE TO ONE INUNDATION
UNDER PROJECT CONDITIONS

Island-group	Agricultural acreage	Flood damage per acre 1/ in dollars	Island group damage 2/	1980 Frequency of inundation	1980 damage 2/	2000 Frequency of inundation	2000 damage 2/	2020 Frequency of inundation	2020 damage 2/
Isleton	42,760	288.30	12,327.7	.001	12.3	.00114	14.1	.00128	15.8
Lodi	51,735	283.10	14,646.2	.001	14.6	.00114	16.7	.00128	18.7
SUBTOTAL 3/	94,495		26,973.9		26.9		30.8		34.5
Brentwood	24,792	269.80	6,688.9	.001	6.7	.00114	7.6	.00128	8.6
Holt	90,470	288.00	26,055.4	.001	26.1	.00114	29.7	.00128	33.4
Sherman	9,498	226.50	2,151.3	.001	2.2	.00114	2.5	.00128	2.8
Tracy	9,002	297.40	2,677.2	.001	2.7	.00114	3.1	.00128	3.4
TOTAL 3/	228,257		64,546.7		64.6		73.7		82.7

1/ Includes flood damage to crops and cost to reclaim land.
2/ Average annual amount in thousands of dollars.
3/ Only the Isleton and Lodi island-groups are in the Typical Alternative Delta Water Project, while all island-groups are in the Comprehensive Delta Water Project.

The total 1960 present worth of the benefit due to reduced crop losses and savings in reclamation costs during the analysis period 1960-2020 has been determined to be $5,168,000 for the Typical Alternative Delta Water Project and $7,629,000 for the Comprehensive Delta Water Project. The average annual flood damage prevention benefit per acre subsequent to project completion would be $4.70 for the Typical Alternative Delta Water Project and $2.80 for the Comprehensive Delta Water Project. Table 25 shows the benefit to each of the six island-groups. Table 26 summarizes the present worth value of the benefits and outlines the projected date on which the staging of benefits will accrue.

Comparison of Nonproject and Project Flood Maintenance Costs

Subsidence and consolidation of the highly compressible organic soils necessitate periodic raising of the levees in order to maintain adequate flood protection. Since roads within the Delta are usually constructed on the levee crowns, the roads must be rebuilt following levee reconstruction.

The low shearing strength of the soil underlying many of the Delta levees has caused frequent reconstruction of some levee sections and has limited levee heights. Attempts to raise levees underlain by weak foundations to desired heights for flood protection has produced shear failures in the levee.

For the purposes of this study the flood maintenance costs are considered to be all costs of levee maintenance, expenditures for flood fighting, and a portion of each reclamation district's general expenditures. All other reclamation district costs are considered to be drainage costs and are discussed in the section on seepage control benefits.

The cost of levee maintenance includes levee repair, replacement of roads due to levee raising, bank protection, rodent control, levee clearing, and inspection.

TABLE 25

AVERAGE ANNUAL BENEFIT DUE TO REDUCED INUNDATIONS 1/

(In thousands of dollars)

Island group	1960	1980	2000	2020
Isleton				
Costs without project	224.5	257.6	286.6	307.6
Costs with project		12.3	14.1	15.8
Benefits		245.3	272.5	291.8
Lodi				
Costs without project	157.9	180.4	201.7	216.3
Costs with project		14.6	16.7	18.7
Benefits		165.8	185.0	197.6
Subtotal 2/				
Costs without project	382.4	438.0	488.3	523.9
Costs with project		26.9	30.8	34.5
Benefits		411.1	457.5	489.4
Holt				
Costs without project	73.7	84.2	94.1	101.1
Costs with project		26.1	29.7	33.4
Benefits		58.1	64.4	67.7
Tracy				
Costs without project	2.7	3.1	3.4	3.7
Costs with project		2.7	3.1	3.4
Benefits		.4	.3	.3
Brentwood				
Costs without project	70.1	80.1	89.5	96.0
Costs with project		6.7	7.6	8.6
Benefits		73.4	81.9	87.4
Sherman				
Costs without project	45.2	52.0	57.9	62.0
Costs with project		2.2	2.5	2.8
Benefits		49.8	55.4	59.2
Total 3/				
Costs without project	574.1	657.4	733.2	786.7
Costs with project		64.6	73.7	82.7
Benefits		592.8	659.5	704.0

1/ Includes benefits due to reduced crop losses and reclamation costs. Tables 23 and 24.
2/ Typical Alternative Delta Water Project.
3/ Comprehensive Delta Water Project.

TABLE 26

BENEFIT DUE TO REDUCED INUNDATIONS 1/

Island group	Agriculture acreage	1960 present worth ($1,000)	Benefits 2/ Average annual benefit ($1,000)	Average annual benefit per acre ($)
Isleton	42,760	3,078.9		
Construction period (1963-79)			55.2	1.29
Full operation (1980-2019)			264.4	6.18
Lodi	51,735	2,088.9		
Construction period (1963-80)			37.3	0.72
Full operation (1981-2019)			179.5	3.47
Subtotal 3/	94,495	5,167.8		
Construction period			92.5	0.98
Full operation			443.9	4.70
Holt	90,470	756.4		
Construction period (1963-79)			14.1	0.16
Full operation (1980-2019)			62.0	0.69
Tracy	9,002	4.5		
Construction period (1963-73)			0.1	0.01
Full operation (1974-2019)			0.3	0.03
Brentwood	24,792	964.1		
Construction period (1963-78)			18.0	0.73
Full operation (1979-2019)			79.0	3.19
Sherman	9,498	736.4		
Construction period (1963-78)			22.0	2.32
Full operation (1979-2019)			53.7	5.65
Total 4/	228,257	7,629.2		
Construction period			146.7	0.64
Full operation			638.9	2.80

1/ Includes benefits due to reduced crop losses and reclamation costs.
2/ Benefits determined from data in Table 25.
3/ Typical Alternative Delta Water Project.

Annual expenditures for flood maintenance costs within the Delta are made by the local reclamation and protection districts, the island operators, the U. S. Corps of Engineers, the Sacramento River Flood Control District, and the Lower San Joaquin River Flood Control District.

The total annual cost of flood maintenance costs in the Delta has been determined to be approximately $4.50 per acre. This figure was developed from information furnished by the Sacramento District of the U. S. Corps of Engineers, from records or reclamation districts, and from interviews with representatives of these districts.

Construction of the Comprehensive or the Typical Alternative Delta Water Projects will materially reduce the local expenditures for flood control.

At present there are 510 miles of levees within the six island groups which would receive additional flood protection if the Comprehensive Delta Water Project is constructed. Under project conditions, annual maintenance costs would be reduced on 294 miles of levee and the Department of Water Resources would maintain 171 miles of project levees. Due to the increased flood protection, a saving in flood fighting costs would also be realized.

The two island groups which are furnished flood protection by the Typical Alternative Delta Water Project are presently protected by 233 miles of levees. Construction of the master levee system would reduce maintenance costs on 143 miles of interior levees. The State will maintain 71 miles of project levees.

The annual benefit due to reduced flood maintenance costs is the sum of the reduction in maintenance costs of interior levees and flood fighting. At the present time these costs are borne by local districts with only emergency funds coming from State and Federal sources.

In order to evaluate the project benefits due to reduced flood control costs it was necessary to determine the present cost and to ascertain the future costs under both project and nonproject conditions. Flood maintenance expenditures under present conditions, the determination of which has been described earlier, were adjusted for future conditions by evaluating the effect of subsidence on levee maintenance costs.

Construction of the master levee system and channel closures by excluding flood flows and high tides from the interior channels, will reduce the required maintenance on these levees. Under nonproject conditions levee maintenance costs have been increased for future subsidence-induced stability problems. It has been assumed that under project conditions the present levee maintenance cost per foot will be sufficient to maintain the interior levees. It has also been assumed that the maintenance cost of the exterior levees, which will continue to be maintained by the Sacramento River and Lower San Joaquin River Flood Control Districts, will not be affected by project operation.

Table 27 shows the annual costs of flood maintenance with and without the master levee system for each of the six island groups and the resultant annual benefit.

The 1960 present worth of the flood control benefit due to reduced maintenance cost is $5,658,000 for the Typical Alternative Delta Water Project; and $12,937,000 for the Comprehensive Delta Water Project. The average annual per-acre benefit of the Comprehensive Delta Water Project is $1.85 during the construction period, and $3.32 after the project is in full operation. Table 28 shows the benefits to island groups.

TABLE 27

ANNUAL BENEFITS DUE TO REDUCED FLOOD MAINTENANCE COSTS

(In thousands of dollars)

Island group	1960	1980	2000	2020
Isleton				
Costs without project	226.9	306.9	374.9	423.9
Costs with project		174.5	190.1	205.0
Benefits		132.4	184.8	218.9
Lodi				
Costs without project	255.0	344.0	379.0	402.0
Costs with project		176.0	176.0	176.0
Benefits		168.0	203.0	226.0
Subtotal				
Costs without project	481.9	650.9	753.9	825.9
Costs with project		350.5	366.1	381.0
Benefits		300.4	387.8	444.9
Holt				
Costs without project	442.8	549.8	633.8	703.8
Costs with project		319.0	319.0	319.0
Benefits		230.8	314.8	384.8
Tracy				
Costs without project	45.3	55.7	55.7	55.7
Costs with project		17.7	17.7	17.7
Benefits		38.0	38.0	38.0
Brentwood				
Costs without project	148.0	182.0	195.0	203.0
Costs with project		90.2	90.2	90.2
Benefits		91.8	104.8	112.8
Sherman				
Costs without projects	48.0	70.0	92.0	113.0
Costs with project		34.3	45.1	55.4
Benefits		35.7	46.9	57.6
Total				
Costs without project	1,166.0	1,508.4	1,730.4	1,901.4
Costs with project		811.7	838.1	863.3
Benefits		696.7	892.3	1,038.1

TABLE 28

PRESENT WORTH BENEFIT DUE TO REDUCED FLOOD MAINTENANCE COSTS[1/]

Island group	Gross acreage	Benefits 2/		
		1960 present worth, in thousands of dollars	Average annual benefit, in thousands of dollars	Average annual benefit, in dollars
Isleton	47,313	2,628.1		
Construction period (1963-79)			81.9	1.73
Full operation (1980-2019)			177.2	3.75
Lodi	55,673	3,029.4		
Construction period (1963-80)			117.2	2.11
Full operation (1981-2019)			191.5	3.44
Subtotal 3/	102,986	5,657.5		
Construction period			199.1	1.93
Full operation			368.7	3.58
Holt	96,652	4,481.5		
Construction period (1963-79)			164.2	1.70
Full operation (1980-2019)			287.1	2.97
Tracy	9,886	503.4		
Construction period (1963-73)			13.9	1.41
Full operation (1974-2019)			39.1	3.96
Brentwood	32,284	1,696.9		
Construction period (1963-78)			73.4	2.27
Full operation (1979-2019)			97.6	3.02
Sherman	10,450	597.4		
Construction period (1963-78)			17.3	1.66
Full operation (1979-2019)			45.4	4.34
Total 4/	252,258	12,936.7		
Construction period			467.9	1.85
Full operation			837.9	3.32

1/ Includes benefits due to reduced maintenance and flood-fighting costs on interior and exterior levees.
2/ Benefits from Table 27.
3/ Typical Alternative Delta Water Project.
4/ Comprehensive Delta Water Project.

Comparison of Nonproject and Project Seepage Control Costs

The present average annual cost of seepage control in the Delta has been calculated to be approximately $3.50 per acre. This figure was obtained by using data appearing in 16 auditors' reports of the annual expenditures for one or more years of 11 Delta reclamation districts. The annual expenditures of the reclamation districts were divided into the following groups: (1) seepage costs, (2) flood maintenance costs, (3) other operation and maintenance costs, (4) miscellaneous equipment costs, and (5) supervisory and administrative costs. Items (3), (4), and (5), were divided between seepage and flood control in proportion to the expenditures for each. Therefore, the seepage control cost includes the annual cost for: canals and ditches; purchase, operation, and maintenance of pumping plants; and a proportional share of the costs which were not expended specifically for either flood or seepage control.

The pumping plant power costs, as determined from the annual reports of the reclamation districts, were verified by using the information obtained from the 1954-55 hydrologic studies conducted on 33 Delta islands and from the hydrologic study presently being conducted on Twitchell Island.

Future costs of seepage control were computed by evaluating the effect of continued subsidence on each component of the seepage control cost.

Pumping costs were increased by the square of the ratio of future seepage rates to present seepage rates. This was done because subsidence not only increases the amount of seepage water to be removed by pumping, but also increases the required pumping life.

Ditching and related drainage costs were increased by the same ratio of future seepage rates to present seepage rates. Increased seepage inflow will require the digging of additional drainage ditches in order to control the ground water table at the desired depth below the land surface.

It was assumed that supervisory and administrative costs would remain at the present rate of approximately 12 percent of the operation and maintenance costs.

The present and future annual costs of seepage control, assuming continued subsidence over the Delta lowlands, are shown in Table 29.

TABLE 29

ESTIMATED ANNUAL COSTS OF SEEPAGE CONTROL IN THE DELTA

(Assuming continued subsidence)

Year	Cost per acre
1960	$3.50
1980	5.00
2000	6.80
2020	8.90

Subsidence, however, will not continue unabated over the entire area. Each year the surface area of organic soils decreases as mineral soils are exposed. The amount of subsidence which can occur in the future is limited by the depth of organic soils. This factor was considered in evaluating future seepage rates in each of the island groups. The present depths of organic soils are shown on Plate 13, "Areas of Peat and Related Organic Sediments".

Construction of either the Typical Alternative or Comprehensive Delta Water Projects would reduce seepage in the Isleton island group (47,300 acres), and in the Lodi island group (55,700 acres). Seepage control costs would be reduced for 241,900 acres of the Delta by construction of the Comprehensive Delta Water Project. The island groups benefited would be Isleton, Lodi, and Brentwood (32,300 acres); Holt (96,700 acres), and Tracy (9,900 acres).

For the purpose of calculating the costs of seepage control, with either the Typical Alternative or the Comprehensive Delta Water Project in operation, it was assumed that the water surface of the interior channels would be maintained five feet lower than the present mean elevation. This could be done in most channels without seriously affecting either navigation or the operation of irrigation siphons. A five-foot reduction of the hydrostatic head would have the same effect as raising the land surface 5 feet. This is equal to 20 years of subsidence at the rate of 1 foot per 4 years.

Seepage control costs under project conditions were calculated by assuming that seepage from the exterior channels would not be affected by the project and seepage from the interior channels would be reduced by the 5-foot reduction in hydrostatic head.

The seepage control benefits for each island group are shown in Table 30.

Summary of Flood and Seepage Control Benefits

Construction of the master levee system and channel closures would benefit the area by reducing flood damages, and by decreasing flood and seepage control costs. The total 1960 present worth of the flood and seepage control benefit is $11,982,000 for the Typical Alternative Delta Water Project, and $23,119,000 for the Comprehensive Delta Water Project. A summary of these benefits is shown in Table 31.

TABLE 30

BENEFITS DUE TO REDUCED COST OF SEEPAGE CONTROL

(In thousands of dollars)

Island group	Gross acreage	Benefit due to reduced cost of seepage control
Isleton	47,313	
1960 present worth		464.1
Average annual benefit (construction period, 1963-79)		9.0
Average annual benefit (full operation, 1980-2019)		39.1
Lodi	55,673	
1960 present worth		692.3
Average annual benefit (construction period, 1963-80)		21.0
Average annual benefit (full operation, 1981-2019)		50.1
Subtotal1/	102,986	
1960 present worth		1,156.4
Average annual benefit (construction period)		30.0
Average annual benefit (full operation)		89.2
Holt	96,652	
1960 present worth		996.1
Average annual benefit (construction period, 1963-79)		24.6
Average annual benefit (full operation, 1980-2019)		75.7
Tracy	9,886	
1960 present worth		61.5
Average annual benefit (construction period, 1963-73)		0.0
Average annual benefit (full operation, 1974-2019)		4.9
Brentwood	32,284	
1960 present worth		339.1
Average annual benefit (construction period, 1963-78)		9.7
Average annual benefit (full operation, 1979-2019)		24.4
Sherman	10,450	
1960 present worth		0.0
Average annual benefit (construction period, 1963-78)		0.0
Average annual benefit (full operation, 1979-2019)		0.0

TABLE 30 (continued)

BENEFITS DUE TO REDUCED COST OF SEEPAGE CONTROL

(In thousands of dollars)

Island group	Gross acreage	Benefit due to reduced cost of seepage control
Total [2/]	252,258	
1960 present worth		2,553.1
Average annual benefit (construction period)		64.3
Average annual benefit (full operation)		194.2

1/ Typical Alternative Delta Water Project.

2/ Comprehensive Delta Water Project.

Vehicular Transportation

The 700 miles of interconnected waterways which enhance the Delta for agriculture, recreation, and navigation have complicated the problem of providing vehicular access to the area. Navigation on the Delta channels precludes the construction of fixed bridges at many locations and therefore necessitates the construction and operation of drawbridges or ferries. Travel from point to point within the Delta is time consuming due to the circuitous routes which are necessary because of the locations of waterway crossings. Additional time delays are caused by drawbridge and ferry operation. Due to a lack of other suitable foundation conditions, many miles of Delta roads are located on the levee crowns. Travel on these narrow winding levee roads is hazardous, particularly in wet weather, because of the possibility of a vehicle leaving the road and plunging into the adjacent channel. In addition to the above-mentioned transportation problems, the Delta area also has a parking problem which will worsen as the recreational use of the area increases. Additional parking areas are needed to handle the large number of automobiles and boat trailers which presently crowd the narrow shoulders of the levee roads.

Project Effects

Construction of either the Comprehensive or the Typical Alternative Delta Water Project would provide vehicular transportation benefits to the Delta. These benefits would be a result of the construction of the master levee system. The channel closures, which would be a part of the master levee system, would materially improve vehicular access from point to point within the Delta and would eliminate the need for several ferries now operated by the counties. Roads which are now on levee crowns would be rebuilt on the berm of the master levee. The berm will provide room for wider roads and for parking areas. A service road, closed to public travel, will be placed on the levee crown to be used for levee inspection and maintenance.

The benefits due to decreased county maintenance costs, and time and distance savings have been evaluated in this report. The benefits due to safer driving conditions and additional parking areas on the master levee berm have not been evaluated.

Typical Alternative Delta Water Project. The Typical Alternative Delta Water Project would provide vehicular transportation benefits to the northern Delta as a result of the construction of 90 miles of new master levees and 23 channel closures. The channel closures will enable San Joaquin County to discontinue the operation of four cable ferries. Channel closures will provide access to areas served by the Staten Island ferry, which operates between Staten Island and Terminous Tract; the Venice ferry, serving Venice Island and Empire Tract; Correia ferry, operating between Terminous and Empire Tracts; and Rindge ferry which serves Rindge Tract from King Island.

County road maintenance costs would also be reduced since the State would assume maintenance of all county maintained levee roads along the master levee alignment. Thirteen miles of San Joaquin County roads and two miles of Sacramento County roads are on the master levee alignment of the Typical Alternative Delta Water Project.

Benefits due to reduced travel times and distances will also be realized by those traveling within or across the Delta. The benefits to agricultural and recreational traffic have been evaluated in this report. Other traffic within the Delta and through traffic will also be benefited, but the benefits have not been evaluated because of the lack of information concerning the movements of this traffic within the area.

Comprehensive Delta Water Project. The Comprehensive Delta Water Project would provide transportation benefits within the area as a result of the construction of 185 miles of new master levees and 41 channel closures. The improved accessibility provided by the channel closures will make it possible for the operation of six ferries to be discontinued. The Staten, Venice, Correia, and Rindge ferries, which are affected by the Typical Alternative Delta Water Project, have been mentioned previously. In addition to the above four ferries, the Comprehensive Delta Water Project would eliminate the need for the Woodward Island and McDonald Island ferries.

Thirty-nine miles of county roads are on levees along the master levee alignment of the Comprehensive Delta Water Project and would be maintained by the State. Twenty-one miles of these roads are in San Joaquin County, 12 miles in Sacramento County, and 6 miles are in Contra Costa County.

A transportation benefit, due to a reduction in travel times and distances, would also be realized by motorists.

Evaluation of Project Benefits

The transportation benefits which have been evaluated in this report are due to reduced county expenditures for ferry operation, road maintenance, and the savings experienced by agricultural and recreational traffic as a result of improved access. The project benefits have been evaluated through the year 2019.

In order to determine the savings which would be effected by the discontinuance of ferry service, the annual costs of ferry operation were determined from records of the San Joaquin County Highway Department. An annual operating cost was calculated for each of the six ferries affected by averaging the operation costs for the 10-year period ending in fiscal year 1959. The following average annual operating costs were determined: Rindge ferry, $17,700; Correia ferry, $12,300; Woodward Island ferry, $15,300; McDonald Island ferry, $17,300; Staten Island ferry, $14,900; and Venice Island ferry, $15,000. The operation of each ferry was assumed to be discontinued in the year following the construction of the channel closure or closures which would provide access to the area being served by the ferry. Construction of channel closures in the Island and Lodi island groups would make it possible to abandon the Correia and Rindge ferries in 1972, and the Staten and Venice ferries in 1975. Closures in the Holt island group would permit abandonment of the McDonald and Woodward ferries in 1974.

The present annual road maintenance cost in the Delta was found to be approximately $500 per mile. This figure was determined from maintenance records of the Sacramento County, San Joaquin County, and Contra Costa County Highway Departments. The annual savings to each county, resulting from elimination of ferry service and reduced road maintenance, are shown in Table 32 for the Typical Alternative and Comprehensive Delta Water Projects.

Transportation benefits to recreational and agricultural traffic were arrived at by determining the value of the time and distance savings which would be made possible by the construction of master levees and channel closures.

TABLE 32

ANNUAL REDUCTION IN COUNTY EXPENDITURES
FOR ROAD AND FERRY OPERATION AND MAINTENANCE

(In Dollars)

Item	Typical Alternative Delta Water Project				Comprehensive Delta Water Project			
	Contra Costa County	Sacramento County	San Joaquin County	Total	Contra Costa County	Sacramento County	San Joaquin County	Total
Roads	$ 0	$1,200	$ 6,500	$ 7,700	$3,250	$ 5,800	$ 10,400	$ 19,450
Ferries	0	0	59,900	59,900	0	0	92,500	92,500
TOTALS	$ 0	$1,200	$66,400	$67,600	$3,250	$ 5,800	$102,900	$111,950

In order to determine the project benefits to recreational traffic, the reduction in travel times to points within the Delta from population centers outside the Delta was calculated. Since Delta recreation is water oriented, the assumption was made that the benefit to recreational traffic would be proportional to the miles of shoreline which would become more accessible, and to the reduction in travel times to these areas.

The evaluation of the travel time saved was based on a value of $9 for a 6-hour recreation day. The $9 figure was developed from studies of expenditures by fishermen made by the California Department of Fish and Game. Included in the cost of a recreation day are the expenditures for equipment, meals, lodging, and automobile expenses. It is recognized that expenditures by Delta recreationists vary over a wide range, depending upon the activity engaged in; and it is assumed that $9 per day is representative of the average expenditure. The benefit resulting from reduced travel distances was based on an automobile operation cost of 4 cents per mile.

Construction of the Typical Alternative Delta Water Project would reduce the travel time from adjacent cities to 41 miles of Delta shoreline by 20 minutes and would reduce the travel time to 7 miles of shoreline by 40 minutes. The Comprehensive Delta Water Project would produce a 20-minute saving to 65 miles of shoreline and a 40-minute saving to 15 miles of shoreline. No attempt was made to evaluate benefits due to savings of less than 20 minutes.

Table 33 shows the present and projected recreation use of the Delta, as developed in the office report on recreation, and the benefits to recreation traffic which would result from the construction of the Typical Alternative or the Comprehensive Delta Water Project. The 1960 present worth of the benefit would be $8,045,000 for the Typical Alternative Delta Water Project, and $13,897,000 for the Comprehensive Delta Water Project.

TABLE 33

ANNUAL TRANSPORTATION BENEFITS
DUE TO IMPROVED RECREATIONAL ACCESS

(In thousands)

Year	Delta recreation use, in user days	Annual benefit	
		Typical Alternative Delta Water Project	Comprehensive Delta Water Project
1960	2,780	$ ---	$ ---
1980	5,175	558	966
2000	8,908	963	1,662
2020	13,878	1,500	2,590

The cost of transporting agricultural products to market would also be reduced by the improved accessibility which would result from construction of a master levee system. The evaluation of the annual benefit to agricultural traffic was based on farm-to-market trucking costs and agricultural productivity. Agricultural productivity is expected to increase in the future, as it has in the past, due to improvements in crops, fertilizers, and farming methods. This increased productivity is reflected in the annual benefits to agricultural traffic shown in Table 34. The 1960 present worth of the benefit to agricultural traffic provided by the Typical Alternative Delta Water Project is $346,000, and the benefit resulting from construction of the Comprehensive Delta Water Project is $1,200,000

TABLE 34

ANNUAL BENEFIT TO IMPROVED AGRICULTURAL TRANSPORTATION

(In dollars)

Year	Benefit	
	Typical Alternative Delta Water Project	Comprehensive Delta Water Project
1980	$33,200	$115,000
2000	40,500	140,300
2020	44,200	153,400

Summary of Transportation Benefits

Construction of either the Typical Alternative or the Comprehensive Delta Water Project will produce transportation benefits by improving vehicular access, by reducing county operation and maintenance costs, and by providing additional parking areas on the berms of the master levee system. The benefit due to reduced county expenditures for ferry operation and road maintenance, and the benefits realized by recreational and agricultural traffic because of improved vehicular access are summarized in Table 35.

The Single Purpose Delta Water Project and the Chipps Island Barrier Project would be constructed and operated as single-purpose water supply projects and would provide no vehicular transportation benefits.

TABLE 35

SUMMARY OF TRANSPORTATION BENEFITS

(In thousands of dollars)

Benefit	Typical Alternative Delta Water Project			
	Recreation	Agriculture	Operation and maintenance savings	Total
Annual benefit				
1980	558.0	33.2	67.6	658.8
2000	963.0	40.5	67.6	1,071.1
2020	1,500.0	44.2	67.6	1,611.8
1960 present worth	8,045.0	346.3	894.2	9,285.5

Benefit	Comprehensive Delta Water Project			
	Recreation	Agriculture	Operation and maintenance savings	Total
Annual benefit				
1980	966.0	115.0	112.0	1,193.0
2000	1,662.0	140.3	112.0	1,914.3
2020	2,590.0	153.4	112.0	2,855.4
1960 present worth	13,897.0	1,200.0	1,520.6	16,617.6

Recreation

The Sacramento-San Joaquin Delta is a popular recreation area because of its many miles of sheltered waterways and its proximity to population centers in the Central Valley and the San Francisco Bay area. Recreation in the Delta is primarily water-oriented. Fishing, cruising, water skiing, and hunting are the most popular recreational activities.

In 1960 the estimated recreational use of the Delta was 2,780,000 user-days. Sixty-two percent of this use was by residents of the adjoining Counties of Sacramento, San Joaquin, Contra Costa, and Solano. Recreationists from the bay area Counties of Alameda, Santa Clara, San Francisco, and San Mateo were responsible for an additional 30 percent of the use. As the populations of these nearby counties increase, the recreation demand on the Delta will also increase. The present and projected populations of these counties and the resultant recreation demand on the Delta are shown in Table 36.

Although the perimeter of the Delta is easily accessible from nearby population centers, travel within the Delta is time-consuming. The 700 miles of interconnected channels and the limited number of vehicular crossings often cause the recreationist to follow circuitous routes when traveling from point to point within the Delta. Additional time delays are caused by drawbridge and ferry operation.

With proper waterway zoning, the Delta channels will be able to handle the projected recreation demand. However, even at present there is a shortage of land available for public recreation use and for parking areas. A recreation survey1/ conducted in 1960

1/ Appendix to Bulletin No. 76, "Recreation".

TABLE 36

PROJECTED POPULATION AND DELTA RECREATION DEMAND
(In thousands)

Area	Percent of 1960 use1/	1960 Population	1960 Recreation use in user-days	1960 Recreation use in user-days per capita	1980 Population	1980 Recreation demand in user-days	2000 Population	2000 Recreation demand in user-days	2020 Population	2020 Recreation demand in user-days
San Joaquin County	27.2	251	756	3.01	470	1,416	810	2,440	1,220	3,675
Contra Costa County	21.8	408	606	1.48	775	1,278	1,275	2,317	1,765	3,509
Alameda County	17.4	900	484	0.54	1,410	759	2,000	1,076	2,540	1,367
Sacramento County	10.7	510	297	0.58	1,010	588	1,670	972	2,300	1,339
San Francisco And San Mateo Counties	6.5	1,178	181	0.15	1,600	245	1,825	279	2,020	309
Santa Clara County	5.9	653	164	0.25	1,285	323	1,870	469	2,425	609
Solano County	2.8	135	78	0.58	310	166	650	702	1,060	2,005
Remainder of state	7.7	11,795	214	0.02	21,340	400	31,900	653	42,670	1,065
TOTAL	100.0	15,830	2,780		28,200	5,175	42,000	8,908	56,000	13,878

1/ Out-of-state use not included.

by the Department of Water Resources revealed that boaters and water skiers are particularly interested in additional picnic areas and beaches. In many portions of the Delta, the only available parking areas for recreationists' automobiles and boat trailers are along the shoulders of the narrow levee roads which, during days of heavy recreational use, impedes the traffic near boat launching facilities.

Project Effects

Departmental procedure for the determination of recreation benefits has centered around the "Trice-Wood Method" which requires a determination of recreation use of the study area with and without the project under consideration. The Delta recreation problem is, however, interrelated with alternative projects which make the use of this method nonapplicable for project formulation. For the purpose of this study (i.e., that of comparing alternative Delta projects), comparative evaluations of benefits to the recreationist have been employed. Upon project selection, a method compatible with other features of the State Water Facilities will be employed prior to final cost allocation; and recommendations will then be submitted to the Legislature for nonreimbursable state allocation.

Construction of the Chipps Island Barrier Project or any of the Delta Water Project alternatives would affect the recreational use of the Delta. The four projects would be detrimental to the Delta fishery in varying degrees, and each project requires channel closures which would impair navigation. The Typical Alternative and Comprehensive Delta Water Projects would provide improved vehicular transportation networks within the Delta, and would also provide additional public land for recreational use.

Chipps Island Barrier Project. The Chipps Island Barrier Project would not include any physical works in the Delta upstream of the barrier. Therefore, the project would not impede boating movement within the Delta. The facilities to be constructed would not include improved vehicular transportation within the area.

Pleasure craft traveling between the Delta and Suisun Bay would pass through navigation locks at the barrier. The lockage of these craft would cause a time delay of approximately 20 minutes. The worth of time delays is more easily determined for commercial vessels than for pleasure craft; in fact, the experience of passing through a lock may add to the boater's enjoyment. For the purposes of this study, the time delays at the barrier have been considered to be an intangible recreational detriment.

The changes in channel regimen caused by the barrier at Chipps Island would affect both the migratory and fresh-water fisheries. The effects of the barrier on each of the more important species found in the Delta are discussed in the fish and game portion of this appendix. It is expected that the population of migratory fish, such as salmon and striped bass, would be significantly reduced by construction of the Chipps Island barrier. However, the population of fresh-water species in the barrier pool should increase.

Single Purpose Delta Water Project. The Single Purpose Delta Water Project would be constructed and operated as a water supply project as shown on Plate 3. Four control structures and six channel closures would be constructed in the Delta to accomplish this purpose. Small craft movement in the Delta would be somewhat restricted by control structures and channel closures. A small craft lock would be included in the Mokelumne River control structure and small craft would pass through the barge lock at the Ryde control structure. Closures at both ends of Fishermans Cut would exclude vessels from that channel. The Holland Cut and Steamboat Slough control structures, and the closures on Old and Middle Rivers and Potato Slough will make it necessary for boaters to follow more circuitous routes.

The existing intake structure at the headworks of the Cross-Delta Canal near Walnut Grove has an overhead clearance of only 6 feet when the gates are open. This prevents many craft from using the canal when traveling between the Sacramento and Mokelumne Rivers. The additional intake works which would be included in the Single Purpose Delta Water Project would be constructed with an overhead clearance of 16 feet with the gates open. This would enable the majority of small craft to travel between the Sacramento and Mokelumne Rivers via the Cross-Delta Canal.

The Single Purpose Delta Water Project would affect the Delta fishery much less than the Chipps Island Barrier Project. It is expected that the population of anadromous species would be only slightly reduced and the project would have little or no affect on fresh-water species.

During construction, small islands in the channels would be used as spoil areas for material dredged from the channels. One thousand nine hundred acres of land suitable for recreational development will be made available in this manner. The development of these areas would be handled by local agencies.

The value of these spoil areas as recreation lands has been assumed to be $400 per acre, and this figure was used in evaluating the recreation benefit of the project. The benefit, at the time the land is available for development in 1975, would be $760,000. The 1960 present worth of the benefit would be $434,000.

Typical Alternative and Comprehensive Delta Water Projects. The Typical Alternative and Comprehensive Delta Water Projects would be multipurpose projects providing improved vehicular access, flood control, and seepage control to portions of the Delta as shown on Plates 4 and 5 respectively. The necessary channel closures would restrict small craft movements. The Typical Alternative Delta Water Project would include 20 channel closures and 3 control structures, and the Comprehensive Delta Water Project would have 37 channel closures and 4 control structures. Small craft locks and portage facilities would be provided so that the interior channels of the island-groups would be accessible. The Typical Alternative Delta Water Project would have two small craft locks and five small craft portage facilities. Included in the Comprehensive Delta Water Project would be 5 small craft locks and 17 small craft portages.

The additional intake works at Walnut Grove would be identical for the Single Purpose, Typical Alternative, and Comprehensive Delta Water Projects. The effect of the increased clearance on small craft movements has been previously discussed.

The effects of the Typical Alternative and Comprehensive Delta Water Projects on the Delta fishery are discussed in the fish and game chapter of this report. It is expected that the migratory fish population would be slightly reduced by the Typical Alternative and Comprehensive Delta Water Projects.

Construction of the Typical Alternative Delta Water Project would produce 3,800 acres of new public water front land; 5,900 acres would be made available by the Comprehensive Delta Water Project. These acreages would included lands along the master levee right of way and land used as spoil areas. The value of these lands for recreation at the time they are available for recreational development in 1975 has been assumed to be $400. The 1960 present worth of the recreational lands benefit would be $845,000 for the Typical Alternative Delta Water Project, and $1,313,000 for the Comprehensive Delta Water Project.

Summary of Project Effects on Recreation

Each of the four projects discussed in this report would affect the recreational use of the Delta to some degree. The construction of channel closures would generally be detrimental to the Delta fishery and to recreational boating. On the other hand, the channel closures included in the Typical Alternative and Comprehensive Delta Water Projects would be components of improved vehicular transportation systems which would benefit the Delta recreationists. Additional public lands suitable for recreational development would be made available by construction of the Single Purpose, the Typical Alternative, or the Comprehensive Delta Water Project.

The Chipps Island Barrier Project would have only two effects on Delta recreation: (1) the barrier would be detrimental to the Delta fishery; and (2) small craft traveling between the Delta and Suisun Bay would be delayed at the barrier locks. The population of migratory fish would be significantly reduced, while the barrier pool would be beneficial to some fresh-water species, providing an adequate control of rough fish could be attained.

The Single Purpose Delta Water Project would slightly reduce the population of migratory fish. The project's six channel closures and four control structures would restrict small craft movements. Through construction of the project, 1,900 acres of land would be made available for recreational development.

The Typical Alternative Delta Water Project would reduce the population of anadromous fish. Small craft movements would be restricted by 20 channel closures and 3 control structures. Five small craft portage facilities and two small craft locks would be constructed to provide access to the interior channels. Vehicular transportation would be improved by the construction of 80 miles of project roads. The project would provide 3,800 acres of water front lands for recreational development.

The Comprehensive Delta Water Project would reduce the population of anadromous fish. Small craft movements would be restricted by 37 channel closures and 4 control structures. Access to the interior channels would be provided by 17 small craft portage facilities and 4 small craft locks. An improvement in vehicular access would be provided by construction of 179 miles of project roads. The project would also make available 5,900 acres of water front land for recreational development.

Navigation

The Delta channels, particularly the San Joaquin and Sacramento Rivers, receive heavy use from commercial, military, and recreational traffic. Commercial and military use of the Delta Waterways and the effects of the Delta water facilities on this use will be discussed in this chapter.

Water-borne freight movements, which both originate and terminate within the Delta, account for only a small percent of the tonnage transported on the Delta channels. The principal traffic is between ports in the Delta area and ports in the San Francisco Bay area or beyond. The major portion of this external traffic passes through the Ports of Stockton and Sacramento.

Commercial traffic on the San Joaquin River consists of both deep- and shallow-draft vessels. Improvement of the navigation channel was originally authorized in 1876, and in 1926 Congress passed a bill authorizing construction of the Stockton Deep Water Channel. The Port of Stockton has been a regular port of entry for ocean-going vessels since 1933. Prior to completion of the deep-water channel, shallow-draft steamships plied the San Joaquin River carrying both freight and passengers between Stockton and the Bay area. Railroads and highways now carry the passenger traffic, and tug-propelled barges handle the freight movements within the Bay and river system. Military supplies bound for Sharpe's General Depot

Annex and Naval Supply Annex, (both at Stockton), are carried by barges and ocean-going vessels.

The Sacramento River is navigable as far upstream as Red Bluff, 245 river miles north of its mouth. A channel depth of 10 feet at mean lower low water, and a bottom width of 150 to 200 feet, is maintained from Suisun Bay to Sacramento. At present, approximately two million tons of freight are transported by tugboat and barge each year on the Sacramento River. The possibility of a deep-water channel from Suisun Bay to Sacramento was first considered early in this century. Subsequent investigations revealed the engineering and financial feasibility of the project. In 1945 the U. S. Corps of Engineers, Sacramento District, recommended construction of a channel 30 feet deep, by widening and deepening the Sacramento River and Cache Slough for the first 18 miles above Suisun Bay, and by excavating a new channel just inside the easterly boundary of the Yolo Bypass for the remaining 25 miles to Washington Lake in Yolo County near the City of Sacramento. Construction started in 1949, was interrupted by the Korean War, and was resumed in 1956. The deep-water channel, the harbor and turning basin, and a barge canal connecting Washington Lake to the Sacramento River are scheduled for completion in 1963.

Military shipping on the Sacramento River is restricted primarily to vessels moving to and from the Marine Storage Activity at Rio Vista.

As mentioned earlier, only a small percent of the commercial traffic on the Delta's waterways is intra-Delta. Sugar beets, which are transported by barge to a processing plant near Tracy, make up the major portion of these internal freight movements.

Petroleum and petroleum products constitute the largest single class of commodities transported on the Delta channels. Food products are next to petroleum products in annual water-borne tonnages. The tonnages of each of these commodities transported on the Sacramento and San Joaquin Rivers are shown in Table 37 for the years 1950 through 1959. Table 38 shows the number of trips made by steamers, motor vessels, and barges on the two rivers during the period 1950 through 1959.

In order to evaluate the effects of the Delta water facilities on Delta navigation it was necessary to estimate future water-borne commerce. Consideration was given to the effects of the Sacramento Deep Water Channel, population and industrial growth in the Central Valley, and competition from other forms of transportation.

The use of petroleum and petroleum products in the Central Valley is expected to increase in the future, mainly due to population growth and the increase in the number of automobiles within the service area of the two principal ports. It has been assumed that the percentage of petroleum products

TABLE 37

COMMERCIAL NAVIGATION TONNAGES
SACRAMENTO AND SAN JOAQUIN RIVERS

Year	San Joaquin River				Sacramento River			
	Petroleum & petroleum products	Farm produce and food products	Other commodities	Total	Petroleum & petroleum products	Farm produce and food products	Other commodities	Total
1950	606,141	508,490	380,499	1,495,130	1,077,489	349,322	164,072	1,590,883
1951	623,200	535,014	492,884	1,651,098	1,290,819	418,766	265,638	1,975,223
1952	687,584	615,163	581,100	1,883,847	1,415,786	337,685	135,995	1,889,466
1953	701,499	632,073	646,025	1,979,597	1,544,271	335,221	92,567	1,972,059
1954	845,094	710,658	479,298	2,035,050	1,539,274	269,062	364,115	2,172,451
1955	960,064	812,402	641,473	2,413,938	1,701,732	328,343	198,356	2,228,431
1956	739,360	927,282	1,401,345	3,067,987	1,439,017	243,787	203,736	1,886,540
1957	1,108,290	900,402	1,967,648	3,976,340	2,002,406	452,850	248,273	2,703,529
1958	1,148,876	1,303,500	1,489,171	3,941,547	1,838,027	271,919	149,549	2,259,495
1959	1,161,941	916,697	1,600,787	3,679,425	978,172	137,567	106,527	1,222,266

transported by water will continue at the present rate. Population growth will also increase the economic demand for agricultural products which in turn will increase the annual tonnage of farm produce shipped by water. The projection of water-borne commerce (by commodity) is shown in Table 39.

Project Effects

Each of the four alternative plans which are discussed in this report will interfere with navigation to some extent because of the construction of channel closures which are either necessary to maintain the quality of export water, or to provide flood protection and seepage control. The projects, listed in order of decreasing detriments to navigation, are the Chipps Island Barrier Project, the Comprehensive Delta Water Project, the Typical Alternative Delta Water Project, and the Single Purpose Delta Water Project.

Chipps Island Barrier Project. The Chipps Island barrier would be located a short distance downstream from the confluence of the Sacramento and San Joaquin Rivers. All shipping between the Bay area and points within the Delta or upstream would experience time delays at the barrier.

Two deep-draft navigation locks and one small craft lock would be constructed at the Chipps Island barrier. A tugboat would also be provided at the barrier to assist vessels through the locks. A barge lock would be constructed at the Montezuma Slough closure to serve both barges and small craft.

TABLE 38

COMMERCIAL TRAFFIC ON THE
SACRAMENTO AND SAN JOAQUIN RIVERS

Year	Trips annually on San Joaquin[1/]				Trips annually on Sacramento[1/]			
	Deep-draft vessels	Shallow-draft vessels	Barges	Total	Deep-draft vessels	Shallow-draft vessels	Barges	Total
1950	436	4,421	2,836	7,693	0	5,160	3,781	8,941
1951	308	5,254	3,213	8,775	0	5,669	4,969	10,638
1952	344	4,454	3,279	8,077	0	4,845	4,848	9,693
1953	235	4,806	3,034	8,075	0	5,265	4,933	10,198
1954	420	3,831	2,393	6,644	0	7,235	5,339	12,574
1955	757	3,385	2,423	6,565	0	6,843	5,181	12,024
1956	1,039	2,991	1,784	5,814	0	4,805	4,165	8,970
1957	1,082	3,474	2,965	7,521	0	6,207	5,278	11,485
1958	1,158	3,091	2,408	6,657	0	5,015	4,040	9,055
1959	1,441	1,466	1,260	4,167	0	2,253	2,377	4,630

1/ Includes traffic in both directions on the rivers.

TABLE 39

PROJECTION OF COMMERCIAL NAVIGATION TONNAGES
SACRAMENTO AND SAN JOAQUIN RIVERS

(In thousands)

River and product	1980	2000	2020
Sacramento River			
Petroleum and petroleum products	4,888	9,520	15,420
Farm produce and food products	816	970	1,049
Other commodities	655	1,018	1,461
TOTAL	6,359	11,508	17,930
San Joaquin River			
Petroleum and petroleum products	2,201	4,766	8,408
Farm produce and food products	1,146	1,353	1,473
Other commodities	1,105	1,681	2,697
TOTAL	4,452	7,800	12,578

The navigation detriment of the Chipps Island Barrier Project would result from the time delays experienced by vessels passing through the locks. Deep-draft vessels would be delayed approximately 30 minutes passing through the locks, while tug and barge traffic would be delayed 20 minutes. The monetary value of these time losses has been determined by using operating costs of $135 per hour for deep-draft vessels and $35 per hour for a tug and barge. The cost per lockage would amount to two cents per ton of cargo for steamers and three cents per ton for a tug-propelled barge. Since commercial craft passing the Chipps Island barrier site are usually empty on the return trip, the lockage detriment per ton of cargo delivered would be four cents for deep-draft vessels and six cents for barges. An average value of five cents per ton of cargo has been used in the computation of the navigation detriment to all commercial shipping due to construction of the Chipps Island barrier. The projected annual tonnage which would pass through the locks at Chipps Island, and the resulting navigational detriments, are shown in Table 40.

TABLE 40

PROJECTED ANNUAL DETRIMENT
DUE TO THE
CHIPPS ISLAND BARRIER PROJECT

(In thousands)

Year	Projected tonnage	Detriment at 5¢ per ton
1970	8,476	423.8
1980	10,811	540.6
1990	15,059	753.0
2000	19,308	965.4
2010	24,908	1,245.4
2020	30,508	1,525.4

It has been assumed that there will be a steadily increasing detriment to navigation during the construction period 1964-70. The total 1960 present worth of the detriment to commercial navigation through 2019 (the end of the analysis period), has been determined to be $13,969,000.

The annual tonnage of cargo carried by military vessels past the Chipps Island barrier site during recent years has been equal to two to five percent of the commercial tonnage. The detriment to military navigation has not been evaluated due to lack of data on the cost of operating these vessels.

An emergency navigation access would be included in the barrier because of national defense considerations. A section of the barrier would consist of concrete bins filled with sand. In the event of an emergency the sand would be pumped out and the bins towed out of the channel. This would eliminate time delays at the locks. During the period that the emergency access is open salt water incursion into the barrier pool would impair the barrier's usefulness as a water supply project.

Comprehensive Delta Water Project. Channel closures are necessary in the Comprehensive Delta Water Project to accomplish the purposes of water transfer, flood control, seepage control, and improved vehicular access. These channel closures will produce navigation detriments, such as time delays at locks and longer travel distances caused by the construction of channel closures without locks. The effects on navigation by the control structures at Ryde and Holland Cut, and the channel closures on the South Fork of the Mokelumne River at Little Potato Slough on the Mokelumne River at the San Joaquin River and on Middle River at Bacon Island, have been evaluated.

The Ryde control structure, located on the Sacramento River near Ryde, will direct summer flows of the Sacramento River into the Delta Cross Channel near Walnut Grove and will be opened to allow winter flood flows to pass. A barge lock will be constructed at the control structure to handle Sacramento River traffic. The Sacramento River deep-water channel, when completed in 1963, will reduce barge traffic on the Sacramento River at Ryde. It is expected that the shorter route provided by the deep-water channel will attract all barge traffic except local traffic servicing points south of Freeport on the Sacramento River.

The evaluation of the navigation detriment due to the time delays at the Ryde control structure was determined from the operating costs of tugs and barges, the magnitude of the time delay, and projected river traffic. Since commercial river traffic past Ryde will be related primarily to agricultural productivity after completion of the deep-water channel, the projected traffic reflects anticipated increases in productivity. The projected annual commercial navigation detriment due to the Ryde control structure is shown in Table 41. The structure is scheduled for completion in 1970.

TABLE 41

PROJECTED ANNUAL NAVIGATION DETRIMENT,
RYDE CONTROL STRUCTURE

Year	Annual detriment (In dollars)
1970	7,500
1980	9,100
1990	10,000
2000	11,000
2010	11,500
2020	12,000

The Holland Cut control structure would be closed during periods of low outflow to prevent mixing of poor quality water with water in the Delta Cross Channel. The structure would be opened when necessary to permit flood flows in the San Joaquin River to pass unobstructed.

At present the barge traffic to Mossdale, and to the sugar factory near Tracy, passes through Holland Cut and follows Old River to the Grant Line Canal. Construction of the Holland Cut control structure would force the barges to follow a less direct route, via Columbia Cut and the Delta Cross Channel. The navigation detriment would be due to the increased travel distance and time. The estimated annual Holland Cut commercial navigation detriment is shown in Table 42. The structure will be completed in 1975.

The closure of the South Fork Mokelumne River at Little Potato Slough, and of the Mokelumne River at its confluence with the San Joaquin River, will eliminate barge traffic on the North

TABLE 42

ESTIMATED ANNUAL NAVIGATION DETRIMENT
HOLLAND CUT CONTROL STRUCTURE

Year	Annual detriment
1975	$19,900
1980	21,800
1990	24,000
2000	26,400
2010	27,600
2020	28,800

Fork of the Mokelumne and on that portion of the South Fork of the Mokelumne within the Isleton island-group. Commercial traffic on these channels consist largely of sugar beet barges bound for Tracy.

Subsequent to the construction of the above closures sugar beets grown in the vicinity of Staten and Tyler Islands would probably be shipped to Tracy by rail. The navigation detriment resulting from construction of the closures would be due to the increased shipping costs. The estimated annual commercial navigation detriment, which would result from the Mokelumne River closures, is shown in Table 43. Channel closures will be constructed in the Isleton island-group during 1974.

TABLE 43

ESTIMATED ANNUAL NAVIGATION DETRIMENT
MOKELUMNE RIVER CLOSURES

Year	Annual detriment
1975	$ 9,800
1980	10,600
1990	11,700
2000	12,800
2010	13,500
2020	14,000

The closure of Middle River at Bacon Island would, with the other channel closures in the Holt island-group, provide flood and seepage control and improved vehicular access. After construction of the closure, farm produce would not be transported on Middle River, and it would be necessary to truck the produce approximately two miles to loading points on Old River. The commercial navigation detriment due to the Middle River closure has been based on the additional trucking costs. The estimated annual detriment to commercial navagation due to the Middle River closure is shown in Table 44. Channel closures in the Holt island-group would be constructed in 1973.

TABLE 44

ESTIMATED ANNUAL NAVIGATION DETRIMENT
MIDDLE RIVER CLOSURE AT BACON ISLAND

Year	Annual detriment
1975	$3,600
1980	3,900
1990	4,300
2000	4,800
2010	5,000
2020	5,200

The 1960 present worth of the commercial navigation detriments of the Comprehensive Delta Water Project is $608,000. This is equivalent to an average annual detriment of $41,900 during the period 1970 through 2019.

Typical Alternative Delta Water Project

The commercial navigation detriments of the Typical Alternative Delta Water Project would be due to the construction of the Ryde and Holland Cut control structures, the closure of the South Fork of the Mokelumne River at Little Potato Slough, and the closure of the Mokelumne River at its confluence with the San Joaquin River. Each of these are included in the Comprehensive Delta Water Project and have been discussed earlier. The closure of Middle River at Bacon Island is not included in the Typical Alternative Delta Water Project. The 1960 present worth of the commercial navigation detriments of the Typical Alternative Delta Water Project is $558,000. This is equivalent to an equal annual detriment of $38,400 during the period 1970 through 2019.

Single Purpose Delta Water Project

The Single Purpose Delta Water Project would be constructed as a water supply project and would not provide additional flood control, seepage control, or transportation benefits. For this reason the only obstructions to commercial navigation would be the Ryde and Holland Cut control structures. The navigation detriments of these structures are the same for all three variations of the Delta Water Project. The 1960 worth of the commercial navigation detriment of the Single Purpose Delta Water Project is $412,000, and the equal annual detriment for the period 1970 through 2019 is $28,400.

Summary of Navigation Detriments

The Chipps Island Barrier Project and each variation of the Delta Water Project would be detrimental to navigation because of delays at locks, loss of access to some channels, or longer travel distances necessitated by the construction of channel closures. Commercial navigation detriments have been evaluated in this chapter and the effects of each project on recreational boating are discussed in the recreation chapter of this report. The navigation detriments to military traffic have not been evaluated because of a lack of information on the operating costs of military vessels. In the past, military traffic past Chipps Island has been equal to two to five percent of the commercial traffic. Table 45 summarizes the commercial navigation detriments of the Chipps Island Barrier and Delta Water Projects.

TABLE 45

SUMMARY OF COMMERCIAL NAVIGATION DETRIMENTS

(In dollars)

Project	Commercial navigation detriment	
	1960 present worth	Equal annual equivalent 1970-2020
Chipps Island Barrier Project	13,969,000	962,400
Comprehensive Delta Water Project	608,000	41,900
Typical Alternative Delta Water Project	558,000	38,400
Single Purpose Delta Water Project	412,000	28,400

Fish and Game

The fish and wildlife resources of the Sacramento-San Joaquin Delta are important recreational and commercial assets. Unfortunately, basic data upon the life cycle, habitat, biology, etc., are not available to make a complete analysis of the effects of the proposed projects upon this important resource. The summary of the fish and game resource and the evaluation of project effects upon this resource, as contained in this report, must be considered valid only as a comparison of project effects and not as a finite determination of damage. These analyses have been developed in cooperation with the Department of Fish and Game. A more detailed study of these factors is being initiated and will be conducted during the next three to five years. This more detailed study will evaluate the effects of the selected Delta project and recommend methods of damage alleviation and, where possible, enhancement features.

Anadromous Fisheries

Striped bass, salmon, steelhead, and shad are the most important anadromous species.

Striped Bass. The striped bass is not native to the Pacific Coast but was introduced into California in 1879 when 135 young fish from the Navesink River in New Jersey were placed in the Carquinez Straits at Martinez. In 1882 an additional 300 young stripers were released at Army Point in Suisun Bay. The transplanting of this species was very successful; at present the range of striped bass on the Pacific Coast is from Southern California to Washington.

Sport fishing for the striper has long been popular and a commercial fishery existed until it was outlawed in 1935. The greatest concentration of striped bass in the Pacific Coast is in the San Francisco Bay system and the Sacramento-San Joaquin Delta. In recent years the California striped bass catch has averaged 1,500,000 fish annually.

Salmon. The king salmon, which is the principal salmon specie entering the Sacramento-San Joaquin Delta, is native to the Pacific Coast and with a range from Southern California to Alaska.

Some salmon may be found entering the Sacramento-San Joaquin River system at all times of the year. The bulk of the fish,however, enter in two distinct runs, the first one in the spring, and a larger one in the fall.

Salmon originating in streams tributary to the Delta are important to the commercial salmon fisheries of California, Washington, and Oregon. The annual California salmon catch for the years 1942 through 1959 is shown in Table 46. Over this period, fish originating in streams tributary to the Delta made up approximately 75 percent of the total California catch and about 3,000,00 pounds per year of the Oregon and Washington catch.

TABLE 46

ANNUAL CALIFORNIA COMMERCIAL SALMON CATCH

Year	Salmon catch in pounds	
	Total	Delta origin
1948	7,800,000	5,600,000
1949	6,800,000	5,200,000
1950	7,800,000	6,200,000
1951	7,200,000	5,800,000
1952	7,300,000	5,600,000
1953	8,000,000	6,100,000
1954	9,500,000	7,100,000
1955	12,000,000	9,100,000
1956	11,400,000	7,900,000
1957	5,300,000	3,000,000
1958	3,700,000	2,700,000
1959	6,800,000	5,400,000

Salmon fishing is increasing in popularity as shown in Table 47. The bulk of the catch is in the ocean, but there is also substantial river fishing. It is estimated that approximately 75 percent of the sport catch, like the commercial catch, is of fish originating in streams tributary to the Sacramento-San Joaquin Delta.

TABLE 47

TRENDS IN CALIFORNIA SALMON ANGLING

Year	Total catch	Successful anglers
1946	291,000	50,000
1948	321,000	65,000
1949	298,000	67,000
1951	564,000	79,000
1953	640,000	110,000
1954	860,000	142,000
1956	715,000	140,000
1957	700,000	147,000

Steelhead. The steelhead rainbow trout is native to the Pacific Coast with a range from Lower California to Alaska. It is the same species as the inland rainbow trout, differing, mainly, in spending a portion of its life in the ocean.

Some steelhead may be found entering the Delta all during the year, but the major runs occur in the winter and early spring when the fish spawn. It is illegal to take steelhead commercially in California, but they are a popular game fish. In recent years the California steelhead catch has been near 500,000 fish annually.

Shad. The American shad was first introduced into California in 1871, when 10,000 fry were released in the Sacramento River. Shad are now found on the Pacific Coast from San Diego to Alaska. Shad are considered an excellent game fish but support only a minor sport fishery in California. A commercial fishery existed in the lower Delta until it was outlawed in 1957.

Fresh-water Fisheries

Catfish and black bass are the most important fresh-water fishes found in the Delta. Other species, such as Sacramento smelt, fresh-water smelt, carp, bluegill, and black crappie, serve to some extent as food for striped bass and other game fishes and provide minor sport and commercial catches.

The white catfish is the most important Delta fresh-water fish and provides 95 percent of the local catfish catch. Sport fishing for catfish is popular and the estimated annual catch in the Delta is 3,500,000 fish. A commercial fishery existed until 1953.

Wildlife

Waterfowl. The Sacramento-San Joaquin Delta and the San Francisco Bay area are important wintering areas for ducks and geese. The State of California lies on the Pacific Flyway, which encompasses an area extending from Alaska to Central America. The waterfowl breeding grounds are in the northern portion of this migratory range while the southern portions provide feeding and resting areas during the winter months.

Two waterfowl areas are maintained in the Delta by the California Department of Fish and Game--the 1,877-acre Suisun Waterfowl Refuge in Solano County, and the 8,600-acre Grizzly Island Waterfowl Management Area. Controlled shooting is allowed on Grizzly Island, but the Solano County area is maintained solely as a refuge.

In addition to the governmental areas, there are over 60,000 acres of waterfowl wintering areas in the Delta which are maintained by private duck clubs.

The California Department of Fish and Game estimated the 1956 waterfowl kill in the Delta and Suisun marshland areas as 544,000 ducks and 20,000 geese.

Miscellaneous Species. Pheasant and other game birds, such as quail and doves, are also found in the Delta. These species are not expected to be seriously affected by the construction of the Chipps Island barrier or any variation of the Delta Water Project.

Project Effects

The Chipps Island Barrier Project or any variation of the Delta Water Project would alter the fish and wildlife habitat of the Delta. These changes would benefit some species, but the majority would be adversely affected.

Chipps Island Barrier Project

Under present conditions, the fresh waters of the rivers entering the Sacramento-San Joaquin Delta gradually merge with the saline waters of the San Francisco Bay system, thus creating an extended reach of brackish water. This area of brackish water enables migrating fishes to gradually become accustomed to salinity changes. In addition, the brackish water environment of the lower Delta supports a species of amphipod which is the main food item for the white catfish.

Construction of the Chipps Island Barrier Project would create a pool of high quality water behind the barrier and the reduced fresh-water outflow would cause an increase in the salinity of the waters below the barrier. At some times during the year the water temperatures on the two sides of the barrier would differ by several degrees. The temperature difference would be largest in the fall when striped bass and steelhead are returning to the Sacramento and San Joaquin River systems to spawn.

The sudden changes in salinity and water temperature would be extremely detrimental to fishes passing the barrier through fishways or navigation locks, for fishes subjected to a sudden environmental change suffer a physiological shock which may cause death. Striped bass are especially susceptable to shock. Experiments have revealed that the mortality rate of striped bass which are transferred rapidly from salt water to fresh water is about 75 percent.

The Chipps Island barrier would reduce the available spawning area for striped bass and shad by excluding tidal currents from the Delta channels. The elimination of suitable spawning areas in the Delta would probably cause more fish to spawn in the Sacramento and Feather Rivers. However, it is doubtful that these areas could accommodate the entire populations of striped bass and shad.

Anadromous fish migrating to the ocean are guided by river currents. With the Chipps Island barrier in operation and increased exports of water from the Delta, the prevailing currents during most of the year would be toward the state and federal pumping plants in the southern Delta. Fish screens would prevent the majority of the larger fish from being drawn into the pumps, but a considerable number of eggs and fry would be lost.

Fishways would be constructed at the barrier to pass migrating fish, and a number of fish would pass through the navigation locks during normal locking operations. During periods of high inflow to the Delta the floodgates would be opened to allow the flood waters to pass. At these times the fish migrating to the ocean could pass through the floodways.

Under present conditions the pollutants which enter the Delta channels are diluted by tidal action. Industrial, municipal, and agricultural wastes which would enter the quiet waters of the barrier pool would not be as quickly diluted and the fish habitat might be seriously affected in some portions of the barrier pool.

The Chipps Island Barrier Project would be detrimental to several species of anadromous and fresh-water fishes, but the striped bass would be the most seriously affected.

It is expected that the sudden salinity and temperature changes experienced by the migrating stripers as they cross the barrier would be fatal to a large percentage of the fish. As mentioned earlier, 75 percent of a group of striped bass which were rapidly transferred from salt water to fresh water died of shock. The reduced spawning area which would result from the exclusion of tidal currents in the Delta would also adversely affect the population of this species. Eggs and fry passing fish screens at the Delta and Tracy pumping plants would be lost, further reducing the striped bass population.

There is a possibility that a landlocked form of striped bass may develop in the barrier pool. However, there would probably not be sufficient food behind the barrier to sustain a large population.

The Chipps Island Barrier Project would be less detrimental to salmon than to striped bass, but the population would be significantly reduced. The primary reason for the smaller salmon loss is the species greater tolerance to shock. The fish which successfully pass the barrier may experience difficulty locating upstream spawning areas due to the altered currents within the Delta. There would also be a loss of fry at the export pumping plants. A landlocked form of salmon would not develop behind the barrier.

The Chipps Island barrier would result in a smaller commercial salmon catch, hence a monetary loss. It has been estimated that the population of Delta origin salmon would be reduced 50 percent by the barrier. During the period 1948 through 1956, commercial fishermen received an average of $2,630,000 per year for Delta origin fish caught off the coasts of California, Washington, and Oregon. A 50-percent reduction in catch would produce an annual loss of $1,315,000 to commercial fishermen. The present worth of the detriment during the analysis period ending in 2019 would be $19,085,000.

The effect of the project on steelhead trout would be similar to the effect on salmon. However, fewer downstream migrants would be lost. Steelhead remain in fresh water for a year before migrating to the ocean, and therefore the downstream migrants are larger than the downstream migrant salmon. Steelhead, like striped bass, may develop a landlocked form behind the barrier.

It is expected that the project effect on shad will be similar to the effect on striped bass.

The white catfish is native to coastal streams where its major food item, an amphipod, is found in brackish water. The absence of brackish water on the upstream side of the barrier and the resultant reduction in food supply would probably significantly reduce the population of white catfish. It is expected that a reduction of the white catfish population would be partially offset by increases in the populations of brown bullheads and black bullheads in the fresh water of the barrier pool.

Conditions in the barrier pool would be particularly suitable for black bass. This species would probably become one of the most important game fish in the Delta.

The populations of warm water species such as crappie and bluegill should increase.

The waterfowl habitat above the barrier would not be significantly affected. The Suisun and Napa marshlands provide a food supply for wintering waterfowl. The increase in the salinity of the water flooding these areas, resulting from the construction of a barrier at Chipps Island, could reduce the plant yields. However, the detailed studies necessary to evaluate this possibility have not been completed.

<u>Single Purpose Delta Water Project</u>

The Single Purpose Delta Water Project would have less affect on fish and wildlife than the other projects discussed in this report. Like the Chipps Island Barrier Project, this project would be more detrimental to anadromous fish than to the fresh-water species.

Some of the control structures included in the project would be on routes followed by migrant fish. The Steamboat Slough control structure would prevent migrant fish from following this branch of the Sacramento River. During most of the year no water would be released through this control structure and consequently there would be no flow in Steamboat Slough to attract migrant fish. There would be a continual outflow past the Ryde control structure and a fishway would be constructed to permit migrants to reach spawning areas in the upper Sacramento and American Rivers. The Holland Cut control structure would not include a fishway, but Old and Middle Rivers would be accessible via the Delta Cross Canal.

Many of the fish migrating downstream would follow the flow of water toward the export pumping plants. Proper screening will protect the larger fish, but a large number of eggs and fry will be lost.

Construction of the Single Purpose Delta Water Project would cause a small reduction of the fish population. The population reduction would be greater for the migratory fish than for the fresh-water species.

The commercial salmon catch would be reduced by an estimated 12 percent, causing an annual loss of $316,000. The 1960 present worth of the total detriment during the analysis period would be $4,586,000.

The reduced outflow of the Delta Water Project would produce increased salinities in the upper Bay system. As with the Chipps Island Barrier Project, increased salinities in the Napa and Suisun marshlands could reduce the food supply available for waterfowl wintering in these areas.

Typical Alternative Delta Water Project

Although the Typical Alternative Delta Water Project would be more detrimental to migratory fish than the Single Purpose Delta Water Project, some fresh-water species would benefit.

The master levee system, by enclosing the Isleton and Lodi island-groups, would isolate 8 percent of the Delta water surface from tidal influence, and therefore reduce the spawning area of certain species. However, fresh-water fish, such as black bass and some species of catfish which now populate the quieter sloughs, should do well in these isolated channels.

The Typical Alternative Delta Water Project would restrict export water to a single channel north of the San Joaquin River. This channelization would direct a greater number of downstream migrants toward the export pumps. The loss of eggs and fry at the pumps would be higher for the Typical Alternative Delta Water Project than for the Single Purpose Delta Water Project.

The population of migratory fish would be reduced by the Typical Alternative Delta Water Project, but the populations of some fresh-water species may increase.

It is estimated that the population of salmon originating in streams tributary to the Delta would be reduced 15 percent. The annual loss to the commercial salmon fishery would be $395,000. The present worth of the total detriment during the analysis period ending in 2019 would be $5,738,000.

The project would have the same effect on waterfowl as the Single Purpose Delta Water Project.

Comprehensive Delta Water Project

The master levee system would isolate 14 percent of the Delta's water surface from tidal influence, and would restrict the export water to a single channel through the Delta.

Like the Typical Alternative Delta Water Project, the Comprehensive Delta Water Project would reduce the available spawning area for some migratory species, and would provide an improved habitat for certain fresh-water fish.

The complete channelization of the export water would direct large numbers of downstream migrants toward the pumping plants. The loss of eggs and fry at the pumps would be greater for the Comprehensive Delta Water Project than for the other variations of the Delta Water Project.

Anadromous species would be more adversely affected by this project than by the Single Purpose or the Typical Alternative Delta Water Project. However, the isolated interior channels would provide an improved habitat for black bass and other fresh-water fish.

The commercial catch of salmon originating in streams tributary to the Delta would be reduced by an estimated 17 percent, causing an annual loss of $447,000. The 1960 present worth of the total loss over the period of analysis would be $6,487,000.

The salinity of waters in the Napa and Suisun marshlands would be the same for each variation of the Delta Water Project. The available food supplies for waterfowl would be reduced by the greater salinity which would exist under project conditions.

Comparison of Project Effects on Fish and Game

The fish and wildlife habitat of the Sacramento-San Joaquin Delta and the upper portions of the San Francisco Bay system would be altered to varying degrees by each of the projects discussed in this report. All of the projects would generally be detrimental to fish and wildlife. However, it is expected that three of the projects would create conditions which would benefit certain species of fresh-water fish. A summary of the effects of each project on the various species follows.

Migratory Fish

Striped Bass

Striped bass would be the species most adversely affected by each of the four projects. The Chipps Island Barrier Project would be the most detrimental since fish passing the barrier would be subjected to sudden temperature and salinity changes. Elimination of tidal surge from the Delta channels and increased water exports from the Delta would also be detrimental to striped bass.

Of the four plans, the Single Purpose Delta Water Project would be the least detrimental to striped bass. The increased flows toward the export pumps would attract downstream migrants toward the pumps where the smaller fish and eggs would pass through the fish screens and be lost. Striper migration would also be affected by the Ryde, Steamboat Slough, and Holland Cut control structures. A fishway would be provided at the Ryde structure enabling migrants to reach spawning areas in the upper Sacramento and American Rivers.

The Typical Alternative Delta Water Project would create the same type of detrimental effects as the Single Purpose Delta Water Project. However, greater losses of eggs and fry at the pumping plants would result from the channeling of export water in the northern half of the Delta. This channeling would be accomplished by enclosing the Isleton and Lodi island-groups with master levees. The resulting 8 percent reduction in Delta water surface subject to tidal action would reduce the striped bass spawning area.

The detriments of the Comprehensive Delta Water Project would be similar to the detriments of the other variations of the Delta Water Project. Water destined for export would be restricted to a single channel, causing greater losses of eggs and fry at the pumps, and 14 percent of the Delta water surface would be isolated from tidal influence, thereby reducing the striper spawning area.

Shad

Shad are similar in habit to striped bass and therefore it is expected that they will be similarly affected.

Salmon

Like striped bass, salmon would be most adversely affected by the Chipps Island Barrier Project. Some fish loss will result from salinity and temperature shock at the barrier. Fish successfully crossing the barrier and entering the quiet waters of the barrier pool may experience difficulty reaching upstream spawning areas due to the altered currents within the Delta. In addition, the salmon population would be reduced by the loss of eggs and fry at the export pumps.

The Delta Water Project variations would be detrimental to salmon since the control structures and export pumping would alter the currents which guide salmon to spawning areas, and would also cause a loss of fry at the pumps. The effects of each of the projects on the commercial salmon fishery are shown in Table 48.

TABLE 48

DETRIMENT TO COMMERCIAL SALMON FISHERY 1/
(In thousands of dollars)

Project	Annual detriment full operation	1960 present 2/ worth of detriment
Chipps Island Barrier	1,315	19,085
Single Purpose Delta Water	316	4,586
Typical Alternative Delta Water	395	5,738
Comprehensive Delta Water	447	6,487

1/ Delta origin fish caught off coasts of California, Oregon, & Washington.
2/ Analysis period ending in 2019.

Steelhead

The effect of each project on steelhead would be similar to the project's effect on salmon. However, fewer downstream migrants would be lost at the export pumps since steelhead remain in fresh water for a year after hatching and would be large enough to be effectively screened.

Fresh-water Fish

Catfish

The major food item of the white catfish is an amphipod, which is found in brackish water. The Chipps Island Barrier Plan would eliminate brackish water on the upstream side of the barrier reducing this food supply, and, accordingly, the white catfish population. This would be partially offset by an increase of the brown and black bullheads in the fresh water of the barrier pool.

The Single Purpose Delta Water Project would have little or no effect on the catfish population in the Delta.

The Typical Alternative and Comprehensive Delta Water Projects would not appreciably change the white catfish population. However, the isolation of channels from tidal action by master levees would increase the number of brown and black bullheads within these channels.

Black Bass

The largemouth black bass inhabit the quieter fresh-water sloughs in the Delta. Conditions in the Chipps Island barrier pool would be particularly suitable for black bass, and their species could become the Delta's primary game fish.

The Single Purpose Delta Water Project would have little affect on the black bass population.

Tidal flows and flood waters would be excluded from certain channels by the master levee system of the Typical Alternative and Comprehensive Delta Water Projects, thus improving the black bass habitat.

Waterfowl

Each of the four projects would increase the salinity of the water flooding the Suisun and Napa marshlands. The increased salinity could reduce the yield of plants which provide food for waterfowl wintering in the area.

CHAPTER III. SUMMARY OF COSTS

The development of cost estimates of the alternative Delta Water Facilities is presented in the companion office report, "Plans, Designs, and Cost Estimates".

Schedules of Costs

Schedules of capital, general expense, operation and maintenance, replacement, and energy costs of each of the four projects are presented in Tables 49 through 52. These costs are based upon prices prevailing in the summer of 1960.. Since the costs are presented in the form of schedules per year, interest during construction has not been included.

TABLE 49

SCHEDULE OF COSTS--CHIPPS ISLAND BARRIER PROJECT

(In thousands of dollars)

Year	Capital costs	Operation and maintenance costs, and general expense	Replacement costs	Energy costs	Total costs
1963	2,087.				2,087.0
1964	28,148.				28,148.0
1965	27,635.	7.9	11.5		27,654.4
1966	22,552.	25.7	11.5		22,589.2
1967	34,879.	56.0	58.8		34,993.8
1968	39,249.	56.0	58.8		39,363.8
1969	39,327.	56.0	58.8		39,441.8
1970	1,424.	1,898.4	869.8	28.8	4,221.0
1971	763.	1,900.4	872.2	30.0	3,565.6
1972	5,908.	1,900.4	872.2	31.2	8,711.8
1973		2,057.0	1,028.7	32.4	3,118.1
1974		2,057.0	1,028.7	33.6	3,119.3
1975		2,057.0	1,028.7	34.8	3,120.5
1976		2,057.0	1,028.7	36.0	3,121.7
1977		2,057.0	1,027.7	37.2	3,122.9
1978		2,057.0	1,028.7	38.4	3,124.1
1979		2,057.0	1,028.7	39.6	3,125.3
1980		2,057.0	1,028.7	40.8	3,126.5
1981		2,057.0	1,028.7	42.0	3,127.7
1982		2,057.0	1,028.7	43.2	3,128.9
1983		2,057.0	1,028.7	44.4	3,130.1
1984		2,057.0	1,028.7	45.6	3,131.3
1985		2,057.0	1,028.7	46.8	3,132.5
1986		2,057.0	1,028.7	48.0	3,133.7
1987		2,057.0	1,028.7	49.2	3,134.9
1988		2,057.0	1,028.7	50.4	3,136.1
1989		2,057.0	1,028.7	51.6	3,137.3
1990		2,057.0	1,028.7	52.8	3,138.5
1991		2,057.0	1,028.7	54.0	3,139.7
1992		2,057.0	1,028.7	55.2	3,140.9
1993		2,057.0	1,028.7	56.4	3,142.1
1994		2,057.0	1,028.7	57.6	3,143.3
1995		2,057.0	1,028.7	58.8	3,144.5
1996		2,057.0	1,028.7	60.0	3,145.7
1997		2,057.0	1,028.7	61.2	3,146.9
1998		2,057.0	1,028.7	62.4	3,148.1
1999		2,057.0	1,028.7	63.6	3,149.3

TABLE 49 (continued)

SCHEDULE OF COSTS--CHIPPS ISLAND BARRIER PROJECT

(In thousands of dollars)

Year	Capital costs	Operation and maintenance costs, and general expense	Replacement costs	Energy costs	Total costs
2000		2,057.0	1,028.7	64.8	3,150.5
2001		2,057.0	1,028.7	66.0	3,151.7
2002		2,057.0	1,028.7	67.2	3,152.9
2003		2,057.0	1,028.7	68.4	3,154.1
2004		2,057.0	1,028.7	69.6	3,155.3
2005		2,057.0	1,028.7	70.8	3,156.5
2006		2,057.0	1,028.7	72.0	3,157.7
2007		2,057.0	1,028.7	73.2	3,158.9
2008		2,057.0	1,028.7	74.4	3,160.1
2009		2,057.0	1,028.7	75.6	3,161.3
2010		2,057.0	1,028.7	76.8	3,162.5
2011		2,057.0	1,028.7	78.0	3,163.7
2012		2,057.0	1,028.7	79.2	3,164.9
2013		2,057.0	1,028.7	80.4	3,166.1
2014		2,057.0	1,028.7	81.6	3,167.3
2015		2,057.0	1,028.7	82.8	3,168.5
2016		2,057.0	1,028.7	84.0	3,169.7
2017		2,057.0	1,028.7	85.2	3,170.9
2018		2,057.0	1,028.7	86.4	3,172.1
2019		2,057.0	1,028.7	87.6	3,173.3

TABLE 50

SCHEDULE OF COSTS--SINGLE PURPOSE DELTA WATER PROJECT

(In thousands of dollars)

Year	Capital costs	Operation and maintenance costs, and general expense	Replacement costs	Energy costs	Total costs
1963	2,141.				2,141.0
1964	2,292.				2,292.0
1965		38.3	137.9		176.2
1966		38.3	137.9		176.2
1967		38.3	137.9		176.2
1968	9,324.	38.3	137.9		9,500.2
1969	9,325.	38.3	137.9		9,501.2
1970	6,053.	226.4	218.7		6,498.1
1971	593.	329.3	315.6	9.8	1,247.7
1972		340.5	323.6	19.6	683.7
1973	2,355.	340.5	323.6	29.5	3,048.6
1974	4,291.	340.5	323.6	39.3	4,994.4
1975	2,046.	405.8	342.7	49.1	2,843.6
1976	2,729.	406.2	345.6	58.9	3,539.7
1977	2,729.	406.2	345.6	68.7	3,549.5
1978		406.2	392.2	78.6	877.0
1979		406.2	392.2	88.4	886.8
1980	1,781.	406.2	394.8	98.2	2,680.2
1981	612.	406.2	394.8	109.2	1,522.2
1982		440.7	405.2	120.3	966.2
1983		440.7	405.2	131.3	977.2
1984		440.7	405.2	142.4	988.3
1985		440.7	405.2	153.5	999.4
1986		440.7	405.2	164.5	1,010.4
1987		440.7	405.2	175.6	1,021.5
1988		440.7	405.2	186.6	1,032.5
1989		440.7	405.2	197.7	1,043.6
1990		440.7	405.2	208.7	1,054.6
1991		440.7	405.2	224.8	1,070.7
1992		440.7	405.2	240.9	1,086.8
1993		440.7	405.2	257.1	1,103.0
1994		440.7	405.2	273.2	1,119.1
1995	105.	440.7	406.4	289.3	1,241.4
1996		440.7	406.4	305.4	1,152.5
1997		440.7	406.4	321.5	1,168.6
1998		440.7	406.4	337.6	1,184.7
1999		440.7	406.4	353.7	1,200.8

TABLE 50 (continued)

SCHEDULE OF COSTS--SINGLE PURPOSE DELTA WATER PROJECT

(In thousands of dollars)

Year	Capital costs	Operation and maintenance costs, and general expense	Replacement costs	Energy costs	Total costs
2000		440.7	406.4	369.8	1,216.9
2001		440.7	406.4	387.9	1,235.0
2002		440.7	406.4	405.9	1,253.0
2003		440.7	406.4	424.0	1,271.1
2004		440.7	406.4	442.0	1,289.1
2005		440.7	406.4	460.0	1,307.1
2006		440.7	406.4	478.1	1,325.2
2007		440.7	406.4	496.1	1,343.2
2008		440.7	406.4	514.2	1,361.3
2009		440.7	406.4	532.2	1,379.3
2010	179.	440.7	408.4	550.2	1,578.3
2011		440.7	408.4	566.2	1,415.3
2012		440.7	408.4	582.2	1,431.3
2013		440.7	408.4	598.2	1,447.3
2014		440.7	408.4	614.3	1,463.4
2015		440.7	408.4	630.3	1,479.4
2016		440.7	408.4	646.3	1,495.4
2017		440.7	408.4	662.3	1,511.4
2018		440.7	408.4	678.3	1,527.4
2019		440.7	408.4	694.3	1,543.4

TABLE 51

SCHEDULE OF COSTS
TYPICAL ALTERNATIVE DELTA WATER PROJECT

(In thousands of dollars)

Year	Capital costs	Operation and maintenance costs, and general expense	Replacement costs	Energy costs	Total costs
1963	3,852.				3,852.0
1964	3,101.				3,101.0
1965	827.	37.9	137.3		1,002.0
1966	331.	37.9	137.3		506.2
1967	2,438.	37.9	137.3		2,613.2
1968	9,878.	37.9	137.3		10,053.2
1969	10,197.	37.9	137.3		10,372.2
1970	5,187.	231.2	223.5		5,641.7
1971	3,646.	345.4	328.9	9.8	4,330.1
1972	1,756.	385.0	376.5	19.6	2,537.1
1973	3,135.	385.0	376.5	29.5	3,926.0
1974	6,481.	385.0	376.5	39.3	7,281.8
1975	4,628.	458.8	431.6	49.1	5,567.5
1976	4,370.	459.2	434.5	58.9	5,322.6
1977	3,372.	505.2	448.3	68.7	4,394.2
1978	1,566.	505.2	472.6	78.6	2,622.4
1979	817.	505.2	472.6	88.4	1,883.2
1980	1,666.	538.7	590.7	98.2	2,893.6
1981		564.5	700.3	109.2	1,374.0
1982		564.5	700.3	120.3	1,385.1
1983		564.5	700.3	131.3	1,396.1
1984		564.5	700.3	142.4	1,407.2
1985		564.5	700.3	153.5	1,418.3
1986		564.5	700.3	164.5	1,429.3
1987		564.5	700.3	175.6	1,440.4
1988		564.5	700.3	186.6	1,451.4
1989		564.5	700.3	197.7	1,462.5
1990		564.5	700.3	208.7	1,473.5
1991		564.5	700.3	224.8	1,489.6
1992		564.5	700.3	240.9	1,505.7
1993		564.5	700.3	257.1	1,521.9
1994		564.5	700.3	273.2	1,538.0
1995	105.	564.5	701.5	289.3	1,660.3
1996		564.5	701.5	305.4	1,571.4
1997		564.5	701.5	321.5	1,587.5
1998		564.5	701.5	337.6	1,603.6
1999		564.5	701.5	353.7	1,619.7

TABLE 51 (continued)

SCHEDULE OF COSTS
TYPICAL ALTERNATIVE DELTA WATER PROJECT

(In thousands of dollars)

Year	Capital costs	Operation and maintenance costs, and general expense	Replacement costs	Energy costs	Total costs
2000		564.5	701.5	369.8	1,635.8
2001		564.5	701.5	387.9	1,653.9
2002		564.5	701.5	405.9	1,671.9
2003		564.5	701.5	424.0	1,690.0
2004		564.5	701.5	442.0	1,708.0
2005		564.5	701.5	460.0	1,726.0
2006		564.5	701.5	478.1	1,744.1
2007		564.5	701.5	496.1	1,762.1
2008		564.5	701.5	514.2	1,780.2
2009		564.5	701.5	532.2	1,798.2
2010	178.	564.5	703.5	550.2	1,996.2
2011		564.5	703.5	566.2	1,834.2
2012		564.5	703.5	582.2	1,850.2
2013		564.5	703.5	598.2	1,866.2
2014		564.5	703.5	614.3	1,882.3
2015		564.5	703.5	630.3	1,898.3
2016		564.5	703.5	646.3	1,914.3
2017		564.5	703.5	662.3	1,930.3
2018		564.5	703.5	678.3	1,946.3
2019		564.5	703.5	694.3	1,962.3

TABLE 52

SCHEDULE OF COSTS
COMPREHENSIVE DELTA WATER PROJECT

(In thousands of dollars)

Year	Capital costs	Operation and maintenance costs, and general expense	Replacement costs	Energy costs	Total costs
1963	6,218.				6,218.0
1964	3,381.				3,381.0
1965	1,909.	37.9	87.2		2,034.1
1966	924.	37.9	87.2		1,049.1
1967	3,031.	37.9	87.2		3,156.1
1968	11,638.	37.9	87.2		11,760.1
1969	11,958.	37.9	87.2		12,080.1
1970	7,766.	232.3	178.4		8,176.7
1971	6,305.	346.5	283.8	9.8	6,945.1
1972	6,533.	389.9	332.0	19.6	7,269.5
1973	9,254.	436.1	378.5	29.5	10,098.1
1974	7,519.	506.1	505.0	39.3	8,544.4
1975	5,666.	579.9	560.1	49.1	6,830.1
1976	5,408.	580.3	563.0	58.9	6,585.2
1977	4,411.	626.3	576.8	68.7	5,657.8
1978	2,740.	626.3	603.1	78.6	4,047.7
1969	1,448.	653.6	712.7	88.4	2,812.4
1980	1,666.	710.6	961.0	98.2	3,435.5
1981		736.4	1,070.6	109.2	1,915.9
1982		736.4	1,070.6	120.3	1,927.0
1983		736.4	1,070.6	131.3	1,938.0
1984		736.4	1,070.6	142.4	1,949.1
1985		736.4	1,070.6	153.5	1,960.2
1986		736.4	1,070.6	164.5	1,971.2
1987		736.4	1,070.6	175.6	1,982.3
1988		736.4	1,070.6	186.6	1,993.3
1989		736.4	1,070.6	197.7	2,004.4
1990		736.4	1,070.6	208.7	2,015.4
1991		736.4	1,070.6	224.8	2,031.5
1992		736.4	1,070.6	240.9	2,047.6
1993		736.4	1,070.6	257.1	2,063.8
1994		736.4	1,070.6	273.2	2,079.9
1995	105.	736.4	1,071.8	289.3	2,202.2
1996		736.4	1,071.8	305.4	2,113.3
1997		736.4	1,071.8	321.5	2,129.4
1998		736.4	1,071.8	337.6	2,145.5
1999		736.4	1,071.8	353.7	2,161.6

TABLE 52 (continued)

SCHEDULE OF COSTS
COMPREHENSIVE DELTA WATER PROJECT

(In thousands of dollars)

Year	Capital costs	Operation and maintenance costs, and general expense	Replacement costs	Energy costs	Total costs
2000		736.4	1,071.8	369.8	2,177.7
2001		736.4	1,071.8	387.9	2,195.8
2002		736.4	1,071.8	405.9	2,213.8
2003		736.4	1,071.8	424.0	2,231.9
2004		736.4	1,071.8	442.0	2,249.9
2005		736.4	1,071.8	460.0	2,267.9
2006		736.4	1,071.8	478.1	2,286.0
2007		736.4	1,071.8	496.1	2,304.0
2008		736.4	1,071.8	514.2	2,322.1
2009		736.4	1,071.8	532.2	2,340.1
2010	179.	736.4	1,073.8	550.2	2,539.1
2011		736.4	1,073.8	566.2	2,376.1
2012		736.4	1,073.8	582.2	2,392.1
2013		736.4	1,073.8	598.2	2,408.1
2014		736.4	1,073.8	614.3	2,424.2
2015		736.4	1,073.8	630.3	2,440.2
2016		736.4	1,073.8	646.3	2,456.2
2017		736.4	1,073.8	662.3	2,472.2
2018		736.4	1,073.8	678.3	2,488.2
2019		736.4	1,073.8	694.3	2,504.2

Separable Costs

In order to allocate the costs of a multipurpose project using the separable costs-remaining benefits method, it is necessary to determine the separable cost of each project function. The project cost separable to any function is the incremental cost of including that function in the project. Those costs which are not separable to any of the project functions are termed "joint costs" and will be discussed later in this chapter.

Separable Costs to Transportation

The master levees, which are features of the Typical Alternative and Comprehensive Delta Water Projects, would provide flood and seepage control and, in addition, would make possible the construction of an improved vehicular transportation network. The levees would afford a good foundation for road construction, and the channel closures would greatly improve interisland access.

Certain expenditures for roads would be incurred even without the inclusion of vehicular transportation as a project function. Since some of the existing roads along the master levee alignment would be replaced during construction the annual operation and maintenance of these roads would be the responsibility of the State, as the levees included in the master levee system would be purchased by the State. In addition, service roads would be constructed on the master levees for inspection and maintenance purposes. These service roads would not be open to the public.

The separable costs to vehicular transportation would be only the costs of constructing, operating, and maintaining roads in addition to the present network. In Tables 53 through 56, the separable capital and annual costs to vehicular transportation for the Typical Alternative and Comprehensive Delta Water Projects are shown as the difference between master levee costs with and without road improvements.

The Chipps Island Barrier and Single Purpose Delta Water Projects would be constructed as water supply projects, and therefore none of the costs would be separable to vehicular transportation.

TABLE 53

SEPARABLE CAPITAL COSTS TO TRANSPORTATION
TYPICAL ALTERNATIVE DELTA WATER PROJECT

(In thousands of dollars)

Year	Master levee system: Costs with roads	Master levee system: Costs without roads	Separable capital cost
1963	1,711	1,711	0
1964	827	827	0
1965	827	827	0
1966	331	331	0
1967	331	331	0
1968	331	331	0
1969	647	647	0
1970	1,018	962	56
1971	3,646	3,296	350
1972	1,756	1,422	334
1973	1,755	1,422	333
1974	3,294	2,999	295
1975	1,565	1,247	318
1976	1,565	1,247	318
1977	1,566	1,248	318
1978	1,566	1,248	318
1979	817	791	26
1980	496	471	25
TOTALS	24,049	21,358	2,691

Total 1960 present worth value of the separable capital cost to transportation = $1,536.

TABLE 54

SEPARABLE ANNUAL COSTS TO TRANSPORTATION
TYPICAL ALTERNATIVE DELTA WATER PROJECT

(In thousands of dollars)

Year	Master levee system: Costs with roads	Master levee system: Costs without roads	Separable annual costs
1970			
1971	19.8	19.6	0.2
1972	107.0	105.5	1.5
1973	107.0	105.5	1.5
1974	107.0	105.5	1.5
1975	194.8	191.1	3.7
1976	194.8	191.1	3.7
1977	194.8	191.1	3.7
1978	194.8	191.1	3.7
1979	194.8	191.1	3.7
1980	343.8	289.2	54.6
1981-2019	501.0	375.5	125.5

Total 1960 present worth value of the separable annual cost to transportation = $1,158.7.

TABLE 55

SEPARABLE CAPITAL COSTS TO TRANSPORTATION
COMPREHENSIVE DELTA WATER PROJECT

(In thousands of dollars)

Year	Master levee system		Separable
	Costs with roads	Costs without roads	capital costs
1963	4,958	4,958	0
1964	1,988	1,792	196
1965	1,909	1,712	197
1966	924	822	102
1967	924	822	102
1968	1,479	1,188	291
1969	1,794	1,507	287
1970	3,598	3,254	344
1971	6,226	5,588	638
1972	6,533	5,912	621
1973	7,874	7,235	639
1974	4,177	3,626	551
1975	2,448	1,874	574
1976	2,448	1,875	573
1977	2,449	1,876	573
1978	2,740	2,413	327
1979	1,448	1,422	26
1980	496	471	25
TOTALS	54,413	48,347	6,066

Total 1960 present worth value of the separable capital cost to transportation = 3,742. (Present worth values are used in the allocation of costs.

TABLE 56

SEPARABLE ANNUAL COSTS TO TRANSPORTATION
COMPREHENSIVE DELTA WATER DISTRICT

(In thousands of dollars)

Year	Master levee system		Separable
	Costs with roads	Costs without roads	capital cost
1970	0.9	0.6	0.3
1971	20.7	20.2	0.5
1972	107.9	106.1	1.8
1973	200.6	198.1	2.5
1974	397.1	373.5	23.6
1975	484.9	459.1	25.8
1976	484.9	459.1	25.8
1977	484.9	459.1	25.8
1978	484.9	459.1	25.8
1979	621.8	549.4	72.4
1980	924.5	740.7	183.8
1981-2019	1,081.7	827.0	254.7

Total 1960 present worth value of the separable annual cost to transportation = 2,465.4.

Separable Costs to Flood and Seepage Control

The separable cost to flood and seepage control has been determined to be a percentage of the project costs expended for master levees and channel closures. All costs of master levees not on the Cross-Delta Canal would be separable to flood and seepage control. The cost of that portion of the master levee system on the cross-canal alignment would be treated as a joint cost since dredging of the Cross-Delta Canal for water transfer purposes would provide material for levee construction and bank protection in these reaches, and would serve both the functions of water salvage and that of flood protection. Therefore, the percentage of the master-levee costs of each island-group separable to flood and seepage control has been determined to be the ratio of the length of master levees not on the Cross-Delta Canal alignment, to the total length of the master levee.

The schedules of capital and annual costs of the Comprehensive and Delta Water Projects separable to flood and seepage control appear in Tables 57 and 58. All the island-groups shown in Table 57 would receive flood and seepage protection as a function of the Comprehensive Delta Water Project, but the Typical Alternative Delta Water Project would provide flood and seepage protection to only the Isleton and Lodi island-groups.

Flood and seepage control are not functions of the Chipps Island Barrier and Single Purpose Delta Water Projects, and consequently there are no costs separable to these functions.

Separable Costs to Water Supply

The separable costs to water supply of the Comprehensive and Typical Alternative Delta Water Projects consist of the costs of salinity control structures and appurtenances, structures to control the flow of export water across the Delta, substitute water facilities, and supplemental water facilities.

It is physically possible to identify those project features which are necessary to accomplish the project functions of water salvage, local supplemental water, and local water quality; all of which are components of the water supply function. However, in order to reflect the intent of Chapter 1766 of the 1959 Statutes

TABLE 57

SEPARABLE CAPITAL COSTS OF FLOOD AND SEEPAGE CONTROL
TYPICAL ALTERNATIVE AND COMPREHENSIVE DELTA WATER PROJECTS

(In thousands of dollars)

Year	Master levee system			Typical Alternative D.W.P.*	Master levee system					Comprehensive Delta Water Project
	Isleton	Lodi	Bear Creek diversion		Holt	Tracy	Brentwood	Sherman	Kellogg Creek diversion	
1963	434.8	424.4		859.2	926.2	534	354.0	450		3,121.4
1964	203.0	213.3		416.3	205.4		231.8	97		950.5
1965	203.0	213.3		416.3	205.4		198.2	97		916.9
1966	81.3	85.3		166.6	102.7		99.1	97		465.4
1967	81.3	85.3	120.4	287.0	102.7		99.1	97		585.8
1968	81.3	85.3	120.4	287.0	102.7	366	99.1	97		951.8
1969	229.8	85.3	121.0	436.1	103.4	367	99.5	97		1,103.0
1970	377.9	85.3		463.2	782.6	498	207.1	97		2,047.9
1971	350.2	1,377.5		1,727.7	782.6	498	207.1	97	33.2	3,345.6
1972	350.2	365.6		715.8	783.2	499	1,129.8	96		3,223.8
1973	350.2	365.6		715.8	2,374.4	1,571	207.1	96		4,964.3
1974	1,091.3	365.6		1,456.9	107.2		153.7	96		1,813.8
1975	332.3	291.6		623.9	107.2		153.7	96		980.8
1976	332.3	291.6		623.9	107.9		153.7	96		981.5
1977	332.8	291.6		624.4	107.9		153.7	96		982.0
1978	332.8	291.6		624.4	410.2		184.0	96		1,314.6
1979	150.4	254.3		404.7	410.2					814.9
1980		254.3		254.3						254.3
TOTALS	5,314.9	5,426.8	361.8	11,103.5	7,721.9	4,333	3,728.7	1,898	33.2	28,818.3

Total 1960 present worth of Typical Alternative Delta Water Project capital costs separable to flood and seepage control = 7,097.

Total 1960 present worth of Comprehensive Delta Water Project capital separable to flood and seepage control = 18,947.

* Delta Water Project.

TABLE 58

SEPARABLE ANNUAL COSTS OF FLOOD AND SEEPAGE CONTROL
TYPICAL ALTERNATIVE AND COMPREHENSIVE DELTA WATER PROJECTS

(In thousands of dollars)

Year	Master levee system			Typical Alternative D.W.P.*	Master levee system					Comprehensive Delta Water Project
	Isleton	Lodi	Bear Creek diversion		Holt	Tracy	Brentwood	Sherman	Kellogg Creek diversion	
1970			5.7	5.7			0.3		1.8	7.8
1971	9.2		5.7	14.9			0.3		1.8	17.0
1972	9.2	46.4	5.7	61.3			0.3		1.8	63.4
1973	9.2	46.4	5.7	61.3			38.9		1.8	102.0
1974	9.2	46.4	5.7	61.3	68.6	69.8	38.9		1.8	240.4
1975	49.4	46.4	5.7	105.5	68.6	69.8	38.9		1.8	280.6
1976	49.4	46.4	5.7	105.5	68.6	69.8	38.9		1.8	280.6
1977	49.4	46.4	5.7	105.5	68.6	69.8	38.9		1.8	280.6
1978	49.4	46.4	5.7	105.5	68.6	69.8	38.9		1.8	280.6
1979	49.4	46.4	5.7	105.5	68.6	69.8	68.9	18.9	1.8	329.5
1980	95.6	46.4	5.7	147.7	129.2	69.8	68.9	18.9	1.8	436.3
1981-2020	95.6	93.0	5.7	194.3	129.2	69.8	68.9	18.9	1.8	482.9

Total 1960 present worth of Typical Alternative Delta Water Project annual costs separable to flood and seepage control = 2,189.4.

Total 1960 present worth of Comprehensive Delta Water Project annual costs separable to flood and seepage control= 5,516.4.

(Section 12202 of the Water Code), none of the costs of the component purposes of water supply have been considered to be separable between the beneficiaries of water supply. Section 12202 of the Water Code states:

> "Among the functions to be provided by the State Water Resources Development System, in coordination with the activities of the United States in providing salinity control for the Delta through operation of the Federal Central Valley Project, shall be the provision of salinity control and an adequate water supply for the users of water in the Sacramento-San Joaquin Delta. If it is determined to be in the public interest to provide a substitute water supply to the users in said Delta in lieu of that which would be provided as a result of salinity control no added financial burden shall be placed upon said Delta water users solely by virtue of such substitution. Delivery of said substitute water supply shall be subject to the provisions of Section 10505 and Sections 11460 to 11463, inclusive, of this code."

In keeping within the limitations imposed by the preceding paragraph, costs of the multipurpose Comprehensive and Typical Alternative Delta Water Projects necessary to accomplish the functions of water salvage, local supplemental water, and local water supply have been considered to be separable to the function of water supply as a whole. A schedule of capital and annual costs of the Typical Alternative Delta Water Project separable to water supply appears in Table 59. Costs of the Comprehensive Delta Water Project separable to water supply are shown in Table 60. All costs of the Chipps Island Barrier and Single Purpose Delta Water Projects have been handled as joint costs in the allocation of costs presented in Chapter V.

Separable Costs to Recreation

Additional public lands would be made available for recreational use due to the acquisition by the State of lands

TABLE 59

SEPARABLE COSTS OF WATER SUPPLY
TYPICAL ALTERNATIVE DELTA WATER PROJECT

(In thousands of dollars)

Year	Capital costs	Annual costs	Year	Capital costs	Annual costs
1963	2,141.0		1991		975.5
1964	2,274.0		1992		991.6
1965		175.2	1993		1,007.8
1966		175.2	1994		1,023.9
1967	1,884.0	175.2	1995	105.0	1,041.2
1968	9,324.0	175.2	1996		1,057.3
1969	9,326.0	175.2	1997		1,073.4
1970	4,169.0	444.1	1998		1,089.5
1971		653.7	1999		1,105.6
1972		663.5	2000		1,121.7
1973	1,380.0	673.4	2001		1,139.8
1974	1,381.0	683.2	2002		1,157.8
1975	1,257.0	734.1	2003		1,175.9
1976	999.0	747.2	2004		1,193.9
1977		816.8	2005		1,211.9
1978		826.7	2006		1,230.0
1979		836.5	2007		1,248.0
1980	1,170.0	848.9	2008		1,266.1
1981		859.9	2009		1,284.1
1982		871.0	2010	178.0	1,304.1
1983		882.0	2011		1,320.1
1984		893.1	2012		1,336.1
1985		904.2	2013		1,352.1
1986		915.2	2014		1,368.2
1987		926.3	2015		1,384.2
1988		937.3	2016		1,400.2
1989		948.4	2017		1,416.2
1990		959.4	2018		1,432.2
			2019		1,448.2

& Total 1960 present worth value of the separable cost to water supply equals $39,159.8.

TABLE 60

SEPARABLE COSTS OF WATER SUPPLY
COMPREHENSIVE DELTA WATER PROJECT

(In thousands of dollars)

Year	Capital costs	Annual costs	Year	Capital costs	Annual costs
1963	1,260.0		1991		926.9
1964	1,393.0		1992		943.0
1965		125.1	1993		959.2
1966		125.1	1994		975.3
1967	1,884.0	125.1	1995	105.0	992.6
1968	9,384.0	125.1	1996		1,008.7
1969	9,387.0	125.1	1997		1,024.8
1970	4,168.0	395.5	1998		1,040.9
1971		605.1	1999		1,057.0
1972		614.9	2000		1,073.1
1973	1,380.0	624.8	2001		1,091.2
1974	1,381.0	634.6	2002		1,109.2
1975	1,257.0	685.5	2003		1,127.3
1976	999.0	698.6	2004		1,145.3
1977		768.2	2005		1,163.3
1978		778.1	2006		1,181.4
1979		787.9	2007		1,199.4
1980	1,170.0	800.3	2008		1,217.5
1981		811.3	2009		1,235.5
1982		822.4	2010	179.0	1,255.5
1983		833.4	2011		1,271.5
1984		844.5	2012		1,287.5
1985		855.6	2013		1,303.5
1986		866.6	2014		1,319.6
1987		877.7	2015		1,335.6
1988		888.7	2016		1,351.6
1989		899.8	2017		1,367.6
1990		910.8	2018		1,383.6
			2019		1,399.6

Total 1960 present worth value of the separable cost to water supply equals $36,779.6

necessary for construction of either the Typical Alternative or the Comprehensive Delta Water Projects. Since no project costs would be incurred solely by virtue of recreation being included as a project function, no separable costs have been assigned to recreation. Recreation is not a function of the Chipps Island Barrier or the Single Purpose Delta Water Projects.

Joint Costs

The costs which are not separable to any single function of a multipurpose project are defined as joint costs. Joint costs are costs of features which serve two or more but not all functions of a multipurpose project.

The joint costs of the Typical Alternative and Comprehensive Delta Water Projects consist of the channel dredging costs and the portion of the master levee system and diversions costs which are not separable to the purposes of vehicular transportation, as flood and seepage control or water supply. Schedules of the capital and annual joint costs of the Typical Alternative Delta Water Project are shown in Tables 61 and 62. Joint cost schedules of the Comprehensive Delta Water Project appear in Tables 63 and 64.

Water supply is the only function of the Chipps Island Barrier and Single Purpose Delta Water Projects, and therefore to fulfill the requirements of Section 12202 of the Water Code the total project costs are handled as joint costs to be allocated among the component functions of water salvage, local water supply, and local water quality.

TABLE 61

JOINT CAPITAL COSTS
TYPICAL ALTERNATIVE DELTA WATER PROJECT

(In thousands of dollars)

Year	Master levee system: Isleton	Master levee system: Lodi	Bear Creek diversion	Channel dredging	Total joint capital costs
1963	490.2	361.6			851.8
1964	229.0	181.7			410.7
1965	229.0	181.7			410.7
1966	91.7	72.7			164.4
1967	91.7	72.7	102.6		267.0
1968	91.7	72.7	102.6		267.0
1969	259.2	72.7	103.0		434.9
1970	426.1	72.7			498.8
1971	394.8	1,173.5			1,568.3
1972	394.8	311.4			706.2
1973	394.8	311.4			706.2
1974	1,230.7	311.4		1,806.0	3,348.1
1975	374.7	248.4		1,806.0	2,429.1
1976	374.7	248.4		1,806.0	2,429.1
1977	375.2	248.4		1,806.0	2,429.6
1978	375.2	248.4			623.6
1979	169.6	216.7			386.3
1980		216.7			216.7
TOTALS	5,993.1	4,623.2	308.2	7,224.0	18,148.5

Total 1960 present worth value of the joint capital cost equals $10,916.

TABLE 62

JOINT ANNUAL COSTS
TYPICAL ALTERNATIVE DELTA WATER PROJECT

(In thousands of dollars)

Year	Master levee system: Isleton	Master levee system: Lodi	Bear Creek diversion	Channel dredging	Total joint capital costs
1970			4.9		4.9
1971	10.4		4.9		15.3
1972	10.4	39.5	4.9		54.8
1973	10.4	39.5	4.9		54.8
1974	10.4	39.5	4.9		54.8
1975	55.8	39.5	4.9		100.2
1976	55.8	39.5	4.9		100.2
1977	55.8	39.5	4.9		100.2
1978	55.8	39.5	4.9	24.3	124.5
1979	55.8	39.5	4.9	24.3	124.5
1980	107.7	39.5	4.9	24.3	176.4
1981-2020	107.7	79.2	4.9	24.3	216.1

Total 1960 present worth value of the joint annual cost equals $2,405.3 1/.

1/ Present worth values are used in the allocation of costs.

TABLE 63

JOINT CAPITAL COSTS, COMPREHENSIVE DELTA WATER PROJECT

(In thousands of dollars)

Year	Island-group: Isleton	Island-group: Lodi	Island-group: Holt	Island-group: Brentwood	Bear Creek diversion	Kellogg Creek diversion	Channel dredging	Total joint capital costs
1963	490.2	361.6	498.0	486.0				1,835.8
1964	229.0	181.7	110.6	320.2				841.5
1965	229.0	181.7	110.6	273.8				795.1
1966	91.7	72.7	55.3	136.9				356.6
1967	91.7	72.7	55.3	136.9	102.6			459.2
1968	91.7	72.7	55.3	136.9	102.6		552.0	1,011.2
1969	259.2	72.7	55.6	137.5	103.0		553.0	1,181.0
1970	426.1	72.7	421.4	285.9				1,206.1
1971	394.8	1,173.5	421.4	285.9		45.8		2,321.4
1972	394.8	311.4	421.8	1,560.2				2,688.2
1973	394.8	311.4	1,278.6	285.9				2,270.7
1974	1,230.7	311.4	57.8	212.3			1,961.0	3,773.2
1975	374.7	248.4	57.8	212.3			1,961.0	2,854.2
1976	374.7	248.4	57.8	212.3			1,961.0	2,854.2
1977	375.2	248.4	58.1	212.3			1,962.0	2,856.0
1978	375.2	248.4	220.8	254.0				1,098.4
1979	169.6	216.7	220.8					607.1
1980		216.7						216.7
TOTALS	5,993.1	4,623.2	4,157.3	5,149.3	308.2	45.8	8,950.0	29,226.9

Total 1960 present worth value of the joint capital costs equals 18,252.0.

TABLE 64

JOINT ANNUAL COSTS, COMPREHENSIVE DELTA WATER PROJECT

(In thousands of dollars)

Year	Master levee system				Bear Creek diversion	Kellogg Creek diversion	Channel dredging	Total joint capital costs
	Isleton	Lodi	Holt	Brentwood				
1970				0.3	4.9	2.6	3.7	11.5
1971	10.4			0.3	4.9	2.6	3.7	21.9
1972	10.4	39.5		0.3	4.9	2.6	3.7	61.4
1973	10.4	39.5		53.7	4.9	2.6	3.7	114.8
1974	10.4	39.5	37.0	53.7	4.9	2.6	3.7	151.8
1975	55.8	39.5	37.0	53.7	4.9	2.6	3.7	197.2
1976	55.8	39.5	37.0	53.7	4.9	2.6	3.7	197.2
1977	55.8	39.5	37.0	53.7	4.9	2.6	3.7	197.2
1978	55.8	39.5	37.0	53.7	4.9	2.6	30.0	223.5
1979	55.8	39.5	37.0	95.1	4.9	2.6	30.0	264.9
1980	107.7	39.5	69.6	95.1	4.9	2.6	30.0	349.4
1981-2020	107.7	79.2	69.6	95.1	4.9	2.6	30.0	389.1

Total 1960 present worth of joint annual costs equals 4,405.8.

Alternative Costs

The total cost allocated to any function of a multipurpose project by the separable costs-remaining benefits method cannot exceed either the benefit to that function, or the cost of the most economical single-purpose alternative method of providing the benefit. Therefore, it is necessary to investigate alternative methods of providing the project services and determine the most economical of these alternatives.

Alternative Cost of Water Supply

The Single Purpose Delta Water Project would be the lowest cost single-purpose alternative method of accomplishing the water supply function and, therefore, limits the water supply allocation of the Chipps Island Barrier Plan, and the Comprehensive and Typical Alternative Delta Water Projects. However, in order to suballocate the water supply costs among the beneficiaries of water salvage, local supplemental water, and local water quality, it is necessary to determine the lowest cost alternative or single purpose method of providing these services.

Alternative Cost of Water Salvage. The salvage of water for export can be most economically accomplished by constructing and operating the Single Purpose Delta Water Project. Consequently, the cost of the Single Purpose Delta Water Project allocated to water salvage limits the allocation to water salvage of the Chipps Island Barrier, Comprehensive, and Typical Alternative Delta Water Projects. The 1960 present worth of the Single Purpose Delta Water Project cost allocated to water salvage is $38,227,400.

Alternative Cost of Supplemental Water. The supplementary water facility of the Single Purpose, Typical Alternative, and Comprehensive Delta Water Projects is the Montezuma Aqueduct. This aqueduct would extend from the North Bay Aqueduct to the Antioch-Pittsburg metropolitan area and would serve portions of both Solano and Contra Costa Counties.

For the purposes of cost allocation, alternative costs have been developed for single-purpose projects which would separately serve Contra Costa and Solano Counties. These facilities are a small Montezuma Aqueduct (which would serve Solano County) and the Northeastern Contra Costa Aqueduct (which would serve Contra Costa County).

The small Montezuma Aqueduct would be an 85 cubic-feet-per-second-capacity aqueduct diverting from the North Bay Aqueduct and following the Montezuma Aqueduct alignment to a terminal reservoir approximately 1.5 miles north of Collinsville. The 1960 present worth of the cost of this facility has been estimated to be $3,303,100.

The Northeastern Contra Costa Aqueduct would vary in capacity from 390 cubic feet per second at the Rock Slough intake to 225 cubic feet per second at the Los Medanos pumping plant. This aqueduct would run south of, and parallel to, the Contra Costa Canal to a point near Oakley where it would cross the existing canal and follow a generally westerly alignment to Los Medanos. At Los Medanos a pumping plant would increase the head to 60 feet and discharge the flow into a distribution system. A lateral would be constructed from Los Medanos to the Contra Costa Canal to enable the addition of water to the canal for delivery to points west of Los Medanos. Oil Canyon Reservoir, designed to handle a 12-hour storage of 500 acre-feet for the Contra Costa Canal, would also be a component of the supplementary water facility serving Contra Costa County. The 1960 present worth of the cost of this alternative would be $19,565,400.

Alternative Cost of Agricultural Water Quality. The lowest cost alternative project, having only agricultural water quality as its function, would be the agricultural water facilities of the Single Purpose Delta Water Project. The 1960 present worth of the cost of the agricultural water facilities is $7,012,000. Since the 1960 present worth of the agricultural water quality benefit is $6,036,700, the allocation to this function is limited by the benefit rather than the alternative cost.

Alternative Cost of Municipal and Industrial Water Quality. The Chipps Island Barrier Project and the Delta Water Project variations would provide good quality water at the Contra Costa Canal intake. Without one of these projects in operation future increases in the amount of upstream use and exports of water by the U. S. Bureau of Reclamation would reduce the Delta outflow and necessitate the release of stored water for salinity repulsion. The release of water from upstream storage would be the lowest cost alternative method of providing the municipal and industrial water quality benefit. However, the 1960 present worth of the benefit-cost ($13,877,000) is less than the 1960 present worth of the alternative cost ($96,810,000) and therefore the allocation is limited by the benefit.

Alternative Cost of Flood and Seepage Control

The lowest cost alternative method of providing flood and seepage control to the areas benefited by the Typical Alternative and Comprehensive Delta Water Projects would be to construct master levee systems comparable to the project design. All the costs of a project with the sole function of flood and seepage control would be assigned to the function of flood and seepage control. Since the project cost would obviously exceed the project benefits the alternative cost of providing flood and seepage control has not been computed.

Alternative Cost of Vehicular Transportation

It is economically feasible to include vehicular transportation as a function of the Typical Alternative and Comprehensive Delta Water Projects since the master levee berms would provide a suitable road foundation and the channel closures would eliminate the need for bridges or other waterway crossings. However, the cost of a single purpose vehicular transportation project would be more marginal and require extensive economic study. These studies have not been made but will be undertaken if local interest in this phase of the project is demonstrated. For the purpose of this preliminary allocation no alternative cost has been considered; thus the ceiling of the vehicular transportation benefit is determined by the benefit.

Alternative Cost of Recreation

Lands purchased by the State for construction of either the Typical Alternative or the Comprehensive Delta Water Projects would be made available for recreational use. Since project costs would not be expended to develop these lands for recreational use, the recreational benefit has been assumed to be equal to the cost of the land.

Summary

Allocation of project costs by the separable costs-remaining-benefits method requires that the separable and joint costs be identified and alternative costs determined. These costs have been discussed in this chapter and are summarized in Table 65.

TABLE 65

SUMMARY OF 1960 PRESENT WORTH OF PROJECT COSTS
(1960 present worth in thousands of dollars)

Item	Chipps Island Barrier Project	Single Purpose Delta Water Project	Typical Alternative Delta Water Project	Comprehensive Delta Water Project
Capital cost	154,415.0	30,721.0	44,454.0	64,399.0
Operation and maintenance for life of project	30,886.0	6,279.5	7,760.2	9,802.6
Replacement	15,369.0	6,368.0	9,263.3	12,922.8
Energy	739.0	2,984.3	2,984.3	2,984.3
Total 1960 present worth cost	201,409.0	46,352.8	64,461.8	90,108.7
Separable cost				
Water supply	----	----	39,159.8	36,779.6
Flood and seepage control	----	----	9,286.0	24,463.4
Vehicular transportation	----	----	2,694.7	6,207.4
Joint costs	----	----	13,321.3	22,658.3
Alternative costs				
Water supply (total)	46,352.8	----1/	46,352.8	46,352.8
Water salvage	38,277.4	----1/	38,277.4	38,277.4
Supplemental water--Solano	3,303.1	3,303.1	3,303.1	3,303.1
Supplemental water--Contra Costa	19,565.4	19,565.4	19,565.4	19,565.4
Agricultural water quality	7,012.0	7,012.0	7,012.0	7,012.0
Municipal and industrial water quality	96,810.0	96,810.0	96,810.0	96,810.0

1/ The alternative costs for water supply and water salvage are the Single Purpose Delta Water Project Costs.

CHAPTER IV. ECONOMIC JUSTIFICATION

Before an engineering project is constructed, its economic feasibility must be ascertained. An economic analysis is necessary to insure the most efficient use of the funds available for project construction.

In general, there are several physically feasible projects which would accomplish the desired results. The selection of a project for construction is dependent upon an analysis of the cost of each project and the benefits and detriments resulting from the project construction and operation. A project is termed economically justified if the value of the project benefits is equal to, or greater than, the project cost. If economic analyses have shown two or more projects to be economically justified, the project selected for construction is usually the one which will produce the maximum net benefit.

Economic analysis is used not only to determine a project's justification, but is used also as a guide during project formulation. An analysis of project features may reveal some features which are not economically justified and which should be deleted in order to maximize the project's net benefits.

The economic analysis of an engineering project is based on a comparison of benefits, detriments, and costs, and therefore whenever possible, the dollar value of the benefits and detriments must be determined. Benefits and detriments which are not amenable to a monetary evaluation are termed intangible and are considered qualitatively.

Money has an earning capacity and consequently the value of a cost, benefit, or detriment varies according to the time at which it occurs. A sum of money received at present has a greater value than the same sum received at some time in the future. Because of this fact the project benefits, costs, and detriments are reduced to present worth or equal annual equivalents for the purposes of comparison. An annual interest rate of 4 percent has been used in the economic evaluation of the Delta water facilities.

The Chipps Island Barrier Project and the Delta Water Project variations each have a common purpose of conserving water for local use and for export to the San Joaquin Valley and Southern California. The Comprehensive and Typical Alternative Delta Water Projects would accomplish these common objectives and in addition would provide flood and seepage control, transportation, and recreation benefits.

Economic analyses have shown that the cost of the Chipps Island Barrier Project would exceed the benefits, and have guided the formulation of the Delta Water Project variations--which <u>are</u> economically justified. Table 66 presents a summary of the costs, benefits, and detriments of each project.

The 1960 present worth of the cost of the Chipps Island Barrier Project would be $201,409,000. The project would create water supply benefits having a 1960 present worth of $219,921,700. However, the barrier would be detrimental to navigation and to some species of fish. No attempt has been made to ascertain the monetary value of the detriments to recreational boating and sport fishing, but the 1960 present worth of the detriments to commercial navigation and commercial fisheries has been determined to be $33,053,600. A detriment is actually a negative benefit, and therefore the 1960 present worth of the Chipps Island Barrier Project benefits would be $186,868,100. Consequently the

TABLE 66

SUMMARY OF COSTS, BENEFITS, AND DETRIMENTS
(1960 present worth in thousands of dollars)

Item	Chipps Island Barrier Project	Single Purpose Delta Water Project	Typical Alternative Delta Water Project	Comprehensive Delta Water Project
Benefits				
Water salvage	188,620.0	202,789.0	202,789.0	202,789.0
Local water quality	19,913.7	19,913.7	19,913.7	19,913.7
Supplementary municipal and industrial water	11,388.0	30,368.0	30,368.0	30,368.0
Flood and seepage control	---	---	11,981.7	23,119.0
Vehicular transportation	---	---	9,285.5	16,617.6
Recreation	---	434.0	845.0	1,313.0
Total Benefits	219,921.7	253,504.7	275,182.9	294,120.3
Detriments				
Commercial navigation	13,969.0	412.3	557.6	607.9
Commercial fisheries	19,084.6	4,586.1	5,737.6	6,487.3
Total detriments	33,053.6	4,998.4	6,295.2	7,095.2
BENEFITS MINUS DETRIMENTS	186,868.1	248,506.3	268,887.7	287,025.1
Costs				
Capital	154,415.0	30,721.0	44,454.0	64,399.0
Operation, maintenance and replacement	46,994.0	15,631.8	20,007.8	25,709.7
Total Costs	201,409.0	46,352.8	64,461.8	90,108.7
NET BENEFITS	-14,540.9	202,153.5	204,425.9	196,916.4
BENEFIT-COST RATIO	0.928:1	5.361:1	4.171:1	3.185:1

project would have a benefit-cost ratio of 0.93:1 with a net detriment of $14,540,900.

The Single Purpose Delta Water Project, unlike the Comprehensive and Typical Alternative Delta Water Projects, does not include features to provide flood and seepage protection or transportation benefits to the Delta. The 1960 present worth of the project's water supply benefits would be $253,070,700, plus a $434,000 benefit to recreation as a result of an increase in public lands available for this purpose. Some features of the project would be detrimental to navigation and/or the Delta fishery. The 1960 present worth of the project detriments to commercial navigation and commercial fisheries would be $412,300 and $4,586,100, respectively. Therefore, the 1960 present worth benefits of the Single Purpose Delta Water Project would be $248,506,300. Total project costs would be $46,352,800. The resulting net benefit would be $202,153,500 with a benefit-cost ratio of 5.36:1.

The Typical Alternative Delta Water Project would perform the water supply functions of the Single Purpose Delta Water Projects, and in addition would include a system of master levees and channel closures which would provide flood and seepage protection to the Isleton and Lodi island-groups. The project would also include an improved vehicular transportation network. Benefits to water supply, flood and seepage control, vehicular transportation, and recreation benefits would total $275,182,900, 1960 present worth, while project detriments to commercial navigation and commercial fisheries would be $6,295,200. The 1960 present worth of the project costs would be $64,461,800. Consequently, the 1960 value of the net benefits would be $204,425,900 and the benefit-cost ratio would be 4.17:1.

A comparison of the Single Purpose and Typical Alternative Delta Water Projects reveals that although the Single Purpose Delta Water Project would have a higher ratio of benefits to costs, the Typical Alternative Delta Water Project would have a greater absolute net benefit.

The Comprehensive Delta Water Project would perform the water function of the Single Purpose and Typical Alternative Delta Water Projects; provide flood and seepage protection to the Isleton, Lodi, Holt, Brentwood, Sherman, and Tracy island-groups; and also provide an improved vehicular transportation network. The 1960 value of the project benefits, less detriments would be $287,025,100, and the project costs would be $90,108,700, 1960 present worth. The benefit-cost ratio of the Comprehensive Delta Water Project would be 3.18:1 with 1960 present worth of the net benefits of $196,916,400.

Since the absolute net benefit of the Comprehensive Delta Water Project is less than the absolute net benefit of the Typical Alternative Delta Water Project, the costs of the additional features would exceed the benefits resulting from the inclusion of the additional features. Thus, the incremental benefit-cost ratio indicates that flood and seepage, vehicular transportation, and recreation south of the San Joaquin River would be economically unjustified.

The economic analysis of the Delta water facilities has shown that each variation of the Delta Water Project, other than the Chipps Island Barrier Project, would have a benefit-cost ratio greater than unity. Of the three, the Single Purpose Delta Water Project would have the largest benefit-cost ratio, and the Typical Alternative Delta Water Project would have the greatest absolute excess of benefits over cost. The analysis has also shown that construction of the Chipps Island Barrier Project, and some features of the Comprehensive Delta Water Project, would not be economically justified.

CHAPTER V. ALLOCATION OF COST

Equity demands that those who enjoy benefits resulting from project construction shall pay their fair share of the costs of providing those benefits. The process of deciding to what extent the beneficiaries shall pay for the benefits is called the "cost allocation" procedure. No single method of dividing the costs of a project will meet with the approval of everyone; all the many methods proposed and used are open to debate. The Department of Water Resources has based the cost allocations of the Delta Water Facilities on the methods jointly suggested by seven federal agencies[1/], and Section 12202 of the California Water Code.

Plate 14, "Method of Cost Allocation", shows the distribution of total project costs among the beneficiaries. In order to provide a fair basis for comparison of different cost schedules the interest-bearing character of money must be taken into account. This is done by considering the project benefits and detriments, project costs, and alternative costs to be the sum of money required to be invested in 1960, at 4.0 percent interest, to satisfy the actual cost at the time the cost arises. The result is referred to as the "1960 present worth". The process is analagous to establishment of an annuity to be spent at some future date. Where desirable, the 1960 present worth can be translated back into actual dollar values.

1/ Proposed Practices for Economic Analysis of River Basin Projects, May 1958. This volume is often referred to as the "Green Book".

Allocations are limited in two directions, as maxima and minima. The minima are established by the fact that the total cost allocated to a given purpose will not be less than the separable cost of including that purpose in the project. The maxima are established by the fact that the allocated cost of any single purpose within a multiple-purpose project may not exceed the cost of the most economical single purpose alternative manner of providing the same purpose, nor may the allocated cost exceed the benefits to be derived from the inclusion of the purpose.

Prime Allocation

The 1960 present worth of capital and annual costs were allocated by use of the separable costs-remaining benefits method as set forth in the "Green Book". Alternative costs were compared for single-purpose projects which would provide equal benefits to each of the primary purposes of water supply, flood and seepage control, vehicular transportation enhancement, and recreation. Since the Chipps Island Barrier and the Single Purpose Delta Water Projects satisfy only the purpose of water supply, the total project cost is so allocated.

Allocation of Water Supply Costs

The distribution of water supply costs among water users benefiting from the project has been made by comparing the costs of alternative methods of providing a local water supply in the absence of the Delta projects under consideration. This method reflects the intent of Section 12202 of the California Water Code. The costs were then divided among export water users, western Delta municipal and industrial beneficiaries of water quality improvement, western Delta agricultural beneficiaries of water quality improvement, and water users who would receive a supplemental supply of water in excess of that presently available.

Allocation of Flood and Seepage Control Costs

The distribution of allocated flood control and seepage costs will ultimately be made by the U. S. Corps of Engineers. The total cost will be divided into federal nonreimbursable funds and local costs. Two criteria will be used in making this determination: (1) the provision for the distribution of costs outlined in the Rivers and Harbors Acts of 1936 and 1942; and (2) the policies regarding distribution of reimbursable costs of a multipurpose project as outlined in the federal acts authorizing the construction of New Hogan Dam. Preliminary estimates by the Corps indicate that an appropriate division could be made by allocating costs assignable to reduced inundation and reduced operation and maintenance on interior channels as federal costs, and the remainder as local costs. This is an extremely conservative allocation, in that the federal share allocated by this method is only about one-third of the flood control cost, or about one-half of the total cost allocated to flood and seepage control.

Allocation of Vehicular Transportation Costs

The distribution of costs allocated to transportation enhancement are in proportion to estimated benefits. This distribution is dependent upon confirmation by the legislature for provision of general funds or gas tax funds for repayment of recreational access benefits. The funds are suballocated between the state share for the building of highways and the local share for their operation and maintenance. This is in accord with precedents in the distribution of costs of works constructed by Bay Toll Crossings, in which the capital costs of the San Francisco Oakland Bay Bridge have been repayed by users by means of toll charges while operation and maintenance costs are paid for by gasoline taxes. Allocated costs for agricultural traffic benefits and county road operation and maintenance savings have been assumed to be a responsibility of the counties.

Allocation of Recreation Costs

Recreation costs have been divided between state and local interests. As in the case of transportation enhancement the final allocation will depend upon the concurrence of the California Legislature. The allocation of the state share of recreation costs is based on the Department of Water Resources policy of presently justifiable capital costs of recreation facilities being nonreimbursable. Annual costs would be repaid by local interests or the recreationist.

Allocation of Costs, Chipps Island Barrier Project

The Chipps Island Barrier Project would provide for water supply only. Flood and seepage control, land transportation enhancement, and recreation would not be materially affected by construction or operation of this project. The tangible benefits resulting from the construction and operation of Chipps Island Barrier would, therefore, be approximately equal to those resulting from construction and operation of the Single Purpose Delta Water Project. Since the total cost of the Single Purpose Delta Water Project is less than that of the Chipps Island Barrier Project, the allocation for the Chipps Island Barrier Project is actually limited to the cost of the Single Purpose Delta Water Project. Since the Chipps Island Barrier Project would cost more than the maximum cost which could be allocated to it, the plan is infeasible.

Local interests in the western Delta have suggested that there are intangible benefits which would arise from the construction of the Chipps Island Barrier Project. If this assumption is made, the total cost of the Chipps Island Barrier Project of $201,409,000 may be divided into a water supply cost of $46,352,800 and the remaining $155,056,200, be left unassigned. Presumably this $155,056,200 would have to be paid for by local interests.

Allocation of Costs, Single Purpose Delta Water Project

The Single Purpose Delta Water Project would provide water supply only. This plan may therefore, insofar as water supply is concerned, be considered as an alternative for each of the other plans. Since the Single Purpose Project has the lowest cost of any of the projects, this cost becomes the lower limit of the permissible allocation of costs for providing a water supply.

There are two aspects of water supply: (1) the water salvaged and, therefore, available for export, and (2) water provided for local use.

The limit of the allocation to the beneficiaries of water salvage was based upon the benefit since no less costly alternative exists. Allocations to local water users were based on benefits which would accrue through construction and operation of the Single Purpose Project, or the alternative cost which would accrue to the local water users if the same benefits were to be provided without the construction of State Water

Facilities. In each case the lower amount was taken as the limit of the allocation. This allocation has been made in accordance with the Department of Water Resources' interpretation of Section 12202 of the California Water Code, which states "If it is determined to be in the public interest to provide a substitute water supply to the users in said Delta in lieu of that which would be provided as a result of salinity control, no added financial burden shall be placed upon Delta water users solely by virtue of such substitution."

The allocation is shown in Table 67.

TABLE 67

SINGLE PURPOSE DELTA WATER PROJECT--PRIME ALLOCATION
(1960 present worth in thousands of dollars)

Item	Water salvage	Supplemental water: Contra Costa		Water quality: Municipal & industrial		Total
		Contra Costa	Solano	Municipal & industrial	Agri-cultural	
Benefit	202,789.0	26,482.0	3,886.0	13,877.0	6,036.7	----
Alternative cost	---	19,565.4	3,303.1	96,810.0	7,012.0	----
Limit of allocation	202,789.0	19,565.4	3,303.1	13,877.0	6,036.7	----
Separable cost		1/	1/	1/	1/	
Remaining limit	202,789.0	19,565.4	3,303.1	13,877.0	6,036.7	245,571.2
Joint costs	38,277.4	3,693.1	623.5	2,619.3	1,139.5	46,352.8
Total allocation	38,277.4	3,693.1	623.5	2,619.3	1,139.5	46,352.8

1/ As per section 12202, Water Code

Allocation of Costs, Typical Alternative Delta Water Project

The Typical Alternative Delta Water Project would provide for: (1) water supply, (2) flood and seepage control, (3) vehicular transportation and (4) recreation. These purposes were separated into a preimary allocation of purpose, and then suballocated among project beneficiaries. The allocation is shown schematically on Plate 14.

Primary Allocation

The distribution of costs among each of the project functions of the Typical Alternative Delta Water Project was accomplished by the separable costs-remaining benefits method. Alternative costs for water supply were based upon the Single Purpose Delta Water Project. Flood and seepage control alternative costs were evaluated on the basis of a system of levees and closures which would provide equal benefits to Delta landowners in the absence of any water supply works. It should be noted that this alternative would be economically unjustified with a benefit-cost ratio of 0.25:1. Since it is extremely difficult to formulate an alternative plan for transportation enhancement with equal benefits, an alternative cost for this purpose was not included. A check was made to compare the benefits of a single-purpose road system with the costs, and it was found that a project of approximately the same magnitude had a benefit-cost ratio in the range of 0.8:1. This check was taken as evidence that alternative costs would exceed the benefits; therefore the ceiling of the allocation was controlled by the benefit. Since the benefit to recreation was evaluated on the basis of alternative costs of purchasing comparable lands for recreation purposes, no alternative cost is shown. Since the beneficiaries of recreation are considered to be all the citizens of the State no suballocation is needed. Table 68 presents the primary allocation of the Typical Alternative Delta Water Project costs.

TABLE 68

TYPICAL ALTERNATIVE DELTA WATER PROJECT, PRIMARY ALLOCATION
(1960 present worth in thousands of dollars)

Item	Water supply	Flood and seepage	Trans-portation	Re-creation	Total
Benefit	253,070.7	11,981.7	9,285.5	845.0	
Alternative cost	46,352.8	---	---	---	
Limit of allocation	46,352.8	11,981.7	9,285.5	845.0	
Separable cost	39,159.8	9,286.0	2,694.7		
Remaining limit	7,193.0	2,695.7	6,590.8	845.0	17,324.5
Joint cost	5,530.9	2,072.8	5,067.9	649.7	13,321.3
TOTAL allocation	44,690.7	11,358.8	7,762.6	649.7	64,461.8

Suballocation of Water Supply Costs

That portion of total project costs which was allocated providing water supply was suballocated among the specific beneficiaries in a manner similar to that used in the allocation of the Single Purpose Delta Water Project. The benefits, alternative costs, and thus the limit of the allocation, are the same as in the single-purpose plan. The allocated costs to Delta water users were limited to that which they would have in the absence of the project. Table 69 presents the suballocation.

Suballocation of Flood and Seepage Control Costs

The portion of the total project costs allocated to the purpose of flood and seepage control was divided between local beneficiaries and the Federal Government, in keeping with federal policy controlling non-reimbursable flood control allocations based on benefits. The procedure

TABLE 69

TYPICAL ALTERNATIVE DELTA WATER PROJECT SUBALLOCATION TO WATER SUPPLY
(1960 present worth in thousands of dollars)

Item	Water salvage	Supplemental water: Contra Costa	Supplemental water: Solano	Water quality: Municipal & industrial	Water quality: Agricultural	Total
Benefit*	202,789.0	26,482.0	3,886.0	13,877.0	6,036.7	---
Alternative cost*	---	19,565.4	3,303.1	96,810.0	7,012.0	---
Limit of allocation*	202,789.0	19,565.4	3,303.1	13,877.0	6,036.7	---
Separable cost*		1/	1/	1/	1/	
Remaining limit	202,789.0	19,565.4	3,303.1	13,877.0	6,036.7	245,571.2
Joint costs	36,905.0	3,560.6	601.1	2,525.4	1,098.6	44,690.7
TOTAL allocation	36,905.0	3,560.6	601.1	2,525.4	1,098.6	44,690.7

* Same as Single Purpose Delta Water Project

of the suballocation was to distribute the allocated costs between federal and local interests, in proportion to the benefits which are accepted by the Corps of Engineers as a basis for nonreimbursable funds, and to the benefits which must be reimbursed by local interest. The basis of federal nonreimbursable funds was the benefits resulting from reduced inundation and reduced operation and maintenance costs on interior levees. Those benefits accruing from reduced seepage and reduced operation and maintenance costs of project levees were considered to be reimbursable by local interests. Table 70 presents the suballocation distributed between island groups.

TABLE 70

TYPICAL ALTERNATIVE DELTA WATER PROJECT
SUBALLOCATION TO FLOOD AND SEEPAGE CONTROL BY ISLAND-GROUP
(1960 present worth in thousands of dollars)

Basis of benefit or allocation	Isleton island-group		Lodi island-group		Total	
	Benefit	Allocation	Benefit	Allocation	Benefit	Allocation
Reduced inundation cost	3,078.9	2,918.9	2,088.9	1,980.3	5,167.8	4,899.2
Reduced operation and maintenance cost						
Interior levees	788.7	747.7	835.9	792.4	1,624.6	1,540.1
Project levees	1,839.4	1,743.8	2,193.5	2,079.4	4,032.9	3,823.2
Reduced seepage cost	464.1	440.0	692.3	656.3	1,156.4	1,096.3
Total reduction in flood and seepage costs	6,171.1	5,850.3	5,810.6	5,508.5	11,981.7	11,358.8

The portion of these project costs allocated to federal and local interest are shown in Table 71. It should be emphasized that this suballocation is based upon an assumed procedure which results in an apparently low federal allocation.

TABLE 71

TYPICAL ALTERNATIVE DELTA WATER PROJECT
SUBALLOCATION TO FLOOD AND SEEPAGE CONTROL
FEDERAL-LOCAL OBLIGATION
(1960 present worth in thousands of dollars)

Island-group	Federal	Local	Total
Isleton	3,666.6	2,183.8	5,850.4
Lodi	2,772.7	2,735.7	5,508.4
TOTAL	6,439.3	4,919.5	11,358.8

Suballocation to Vehicular Transportation

The portion of the project costs allocated to vehicular transportation was suballocated between transportation beneficiaries in proportion to the benefits received. Since a large portion of the transportation benefit will be realized by the Delta recreationist, nonreimbursable state funds might be expected for the capital costs of road construction. The reduced costs to the counties for operation and maintenance of road systems, and the benefits to local traffic, have been considered as local obligations. Table 72 presents the benefits and allocated costs derived from these benefits to these aspects.

TABLE 72

TYPICAL ALTERNATIVE DELTA WATER PROJECT
SUBALLOCATION TO TRANSPORTATION
(1960 present worth in thousands of dollars)

Benefit breakdown	Benefit	Allocation
Delta recreation	8,045.0	6,725.6
Through recreation traffic 1/	---	---
Delta agricultural traffic	346.3	289.5
County operation and maintenance	894.2	747.5
TOTAL	9,285.5	7,762.6

1/ Not evaluated due to lack of origin and destination data

Suballocation to Recreation

Those costs suballocated to Delta recreation were apportioned between the State (nonreimbursable) and the recreation user. This suballocation was based upon the recommended state policy of declaring that portion of the capital cost of recreation facilities which is presently justified by use as nonreimbursable. The remainder of the allocated costs would be borne by the recreation user. If the application of gas tax funds for operation and maintenance to this road system is considered as a user payment, the recreationist obligation can be fulfilled.

Allocation of Costs, Comprehensive Delta Water Project

The Comprehensive Delta Water Project would serve the functions of: (1) water supply, (2) flood and seepage control, (3) vehicular transportation, and (4) recreation. The procedure for the allocation of project capital and annual costs, as illustrated on Plate 14, was to first make a primary allocation between project purposes and then suballocate costs among project beneficiaries.

Primary Allocation

The distribution of costs among each of the project functions was accomplished by the separable costs-remaining benefits method. Alternative costs for water supply were based upon the Single Purpose Delta Water Project. Flood and seepage control alternative costs were evaluated on the basis of a system of levees and closures which would provide equal benefits to Delta landowners in the absence of any water supply works. It should be noted that this alternative would be economically unjustified with a benefit-cost ratio of 0.25:1. The separable costs to flood and seepage control, in the case of this project, exceed the estimated benefits of the project. The excess separable costs were therefore carried as unassigned costs. Since it is extremely difficult to formulate an alternative plan for vehicular transportation with equal benefits, an alternative cost was not included. A check was made to compare the benefits of a single-purpose road system with costs, and it was found that such a project cost would exceed the benefits; therefore, the ceiling of the allocation is controlled by the benefit provided by the Comprehensive Delta Water Project. Since the benefit to recreation is evaluated on the basis of alternative costs of acquiring comparable lands for recreation purposes an alternative cost is not considered. The remaining allocation limit after subtraction of the separable cost from the first allocation limit is also deficient to meet the joint costs, and was similarly carried as an unassigned cost. This project is, therefore, economically infeasible. Table 73 presents this allocation.

Suballocation of Water Supply Costs

That portion of total project costs which were allocated to the function of water supply is subsequently suballocated among the beneficiaries in a manner similar to that used in the allocation or suballocation of costs of the Single Purpose Delta Water Project. Allocated costs to Delta water users is limited to that which they would have had in the absence of the project. The benefits, alternative costs, and the limit of the allocation, are the same as in the single-purpose plan. Table 74 presents the allocation of water supply costs.

Suballocation of Flood and Seepage Control Costs

In keeping with federal policy controlling nonreimbursable flood control allocations the portion of the total project costs allocated to the functions of flood and seepage control were suballocated between local beneficiaries and the Federal Government. Benefits are the basis of the suballocation. The procedure involves the distribution of allocated costs between federal and local interests in proportion to (1) the benefits which are accepted by the Corps of Engineers as a basis for expenditure of nonreimbursable funds, and (2) to the benefits

TABLE 73

COMPREHENSIVE DELTA WATER PROJECT PRIMARY ALLOCATION
(1960 present worth in thousands of dollars)

Item	Water supply	Flood and seepage	Transportation	Recreation	Unassigned cost	Total
Benefit	253,070.7	23,119.0	16,617.6	1,313.0		
Alternative cost	46,352.8	---	---	---		
Limit of allocation	46,352.8	23,119.0	16,617.6	1,313.0		
Separable cost	36,779.6	24,463.4	6,207.4	0.0		
Separable cost portion of allocation	36,779.6	23,119.0	6,207.4	0.0		66,106.0
Remaining limit	9,573.2	0.0	10,410.2	1,313.0		21,296.4
Joint costs	9,573.2	0.0	10,410.2	1,313.0	2,706.3	24,002.7
TOTAL allocation[1/]	46,352.8	23,119.0	16,617.6	1,313.0	2,706.3	90,108.7

1/ Based on assumption that the allocated cost cannot exceed the limit, and that any deficiency will be made through a supplemental source (i.e., local assessment). The difference between the allocated and total cost is unassigned.

TABLE 74

COMPREHENSIVE DELTA WATER PROJECT, SUBALLOCATION TO WATER SUPPLY
(1960 present worth in thousands of dollars)

Item	Water salvage	Supplemental water		Water quality		Total
		Contra Costa	Solano	Municipal and industrial	Agricultural	
Benefit	Same as Single Purpose Delta Water Project					
Alternative cost						
Limit of allocation						
Separable cost						
Remaining limit	202,789.0	19,565.4	3,303.1	13,877.0	6,036.7	245,571.2
Joint cost	38,277.4	3,693.1	623.5	2,619.3	1,139.5	46,352.8
TOTAL allocation 1/	38,277.4	3,693.1	623.5	2,619.3	1,139.5	46 352.8

1/ Allocation reflects assumption that allocated costs cannot exceed limit.

which must be reimbursed by local interest. Reduced inundation and reduced operation and maintenance costs on interior levees were considered as a basis of nonreimbursable funds. Those benefits accruing from reduced seepage costs and reduced operation and maintenance costs of project levees were considered for repayment by local interests. Table 75 presents the flood and seepage control suballocation by island-groups.

TABLE 75

COMPREHENSIVE DELTA WATER PROJECT
SUBALLOCATION TO FLOOD AND SEEPAGE CONTROL
BY ISLAND-GROUP
(1960 present worth in thousands of dollars)

Basis of allocation	Island-group					
	Isleton	Lodi	Holt	Tracy	Brentwood	Sherman
Reduced inundation cost	3,078.9	2,088.9	756.4	4.5	964.1	736.4
Reduced operation & maintenance cost						
Interior levees	788.7	835.9	913.2	52.2	299.6	0.0
Project levees	1,839.4	2,193.5	3,568.3	451.2	1,397.3	597.4
Reduced seepage cost	464.1	692.3	996.1	61.5	339.1	0.0
TOTAL REDUCTION IN FLOOD AND SEEPAGE COSTS	6,171.1	5,810.6	6,234.0	569.4	3,000.1	1,333.8

The portion of project costs allocated to federal and local interest is shown in Table 76. It should be emphasized that this suballocation is based upon an assumed procedure which results in an apparently low federal allocation.

TABLE 76

COMPREHENSIVE DELTA WATER PROJECT, SUBALLOCATION TO FLOOD AND SEEPAGE CONTROL FEDERAL-LOCAL OBLIGATION
(1960 present worth in thousands of dollars)

Island-group	Federal	Local	Total
Isleton	3,867.6	2,303.5	6,171.1
Lodi	2,924.8	2,885.8	5,810.6
Holt	1,669.6	4,564.4	6,234.0
Tracy	56.7	512.7	569.4
Brentwood	1,263.7	1,736.4	3,000.1
Sherman	736.4	597.4	1,333.8
TOTAL	10,518.8	12,600.2	23,119.0

Suballocation to Vehicular Transportation

The portion of the project costs allocated to vehicular transportation was suballocated between transportation beneficiaries in proportion to the benefits received. Since a large portion of the transportation benefit is realized by the Delta recreationist, nonreimbursable state funds might be expected for the capital costs allocated to recreation. The reduced costs to the counties for operation and maintenance of road systems, and the benefits to local traffic have been considered as a basis for determining local obligation. Table 77 presents the benefits and allocated costs to these aspects.

TABLE 77

COMPREHENSIVE DELTA WATER PROJECT
SUBALLOCATION TO TRANSPORTATION
(1960 present worth in thousands of dollars)

Benefit breakdown	Benefit	Allocation
Delta recreation	13,897.0	13,897.0
Through traffic (recreational) 1/		
Delta agricultural traffic	1,200.0	1,200.0
County operation and maintenance	1,520.6	1,520.6
TOTAL	16,617.6	16,617.6 2/

1/ Not evaluated due to lack of origin and destination data.
2/ Assume allocation cannot exceed limit.

Summary of Cost Allocations

The primary allocation and suballocations of various project costs between functions and beneficiaries are presented in Table 78. High magnitudes of unassigned costs of the Chipps Island Barrier and Comprehensive Delta Water Projects remain after all justifiable costs are allocated. In the case of the Chipps Island Barrier Project, about 75 percent of the total costs cannot be assigned to any beneficiary because alternative plans provide a more economical solution to the water supply problems. In the Comprehensive Delta Water Project approximately 3 percent of the total cost cannot be assigned.

TABLE 78

SUMMARY OF COST ALLOCATIONS
(1960 present worth in thousands of dollars)

Item	Chipps Island Barrier Project	Single Purpose Delta Water Project	Typical Alternative Delta Water Project	Comprehensive Delta Water Project 1/
Total cost	201,409.0	46,352.8	64,461.8	90,108.7
Water supply allocation	46,352.8	46,352.8	44,690.7	46,352.8
Water salvage	38,277.4	38,277.4	36,905.0	38,277.4
Supplemental water, Contra Costa County	3,693.1	3,693.1	3,560.6	3,693.1
Supplemental water, Solano	623.5	623.5	601.1	623.5
Municipal & industrial quality	2,619.3	2,619.3	2,525.4	2,619.3
Agriculture quality	1,139.5	1,139.5	1,098.6	1,139.5
Flood and seepage control	---	---	11,358.8	23,119.0
Federal	---	---	6,439.3	10,518.8
Local land owners	---	---	4,919.5	12,600.2
Vehicular transportation	---	---	7,762.6	16,617.6
Recreation access	---	---	6,725.6	13,897.0
Local land owners	---	---	289.5	1,200.0
County	---	---	747.5	1,520.6
Recreation	---	---	649.7	1,313.0
Unassigned costs	155,056.2	---	---	2,706.3

1/ Limited allocation.

CHAPTER VI. REPAYMENT OF PROJECT COSTS

The manner of repayment of project costs allocated to each of the beneficiary groups will be the subject of contract negotiations. This chapter assumes methods of repayment in order to evaluate the unit prices to individual recipients of project services. The existing contract between the State of California and the Metropolitan Water District has been used as a guide for the repayment structure. While this is probably valid for the basis of repayment of that portion of total cost allocated to water supply it is not necessarily applicable to project costs of a more local nature and should be considered only as a suggested method of payment.

Water Salvage

The export water users are expected to repay the project costs allocated to water salvage through the purchase of water from the Delta Pool. The water will be priced so that over the repayment period all costs of the State Water Facilities allocated to water conservation and delivery will be repayed by the export water users. A portion of the unit cost of export water from the Delta will be for repayment of the costs of the Delta water facilities allocated to water salvage.

The average value of the Delta water facilities component of the export water unit cost has been determined from the projected Delta Pool demand during the repayment period ending in 2019, and the water salvage allocation of each of the four alternative projects. The allocated costs and the resulting unit costs are presented in Table 79.

TABLE 79

ALLOCATED COST OF WATER SALVAGE
AND INCREMENT OF DELTA POOL PRICE
NECESSARY FOR RECOVERY OF COSTS

Project	Water Conservation Allocation (1960 present-worth)	Cost Per Acre-foot
Chipps Island Barrier Project	$38,277,400	$ 0.661
Single Purpose Delta Water Project	38,277,400	0.661
Typical Alternative Delta Water Project	36,905,000	0.638
Comprehensive Delta Water Project	38,277,400	0.661

The projected future yearly demands for export water for the years 1969, 1979, 1999, 2009, and 2019, and the annual repayment revenues based on the average unit cost figures in Table 79, are presented in Table 80.

TABLE 80

DELTA POOL DEMAND AND REPAYMENT
REVENUES FOR DELTA FACILITIES

Year	Delta Pool demand, (acre-feet)	Export water repayment revenues, in dollars	
		Chipps Island Barrier and Comprehensive and Single Purpose Delta Water Projects	Typical Alternative Delta Water Project
1969	482,000	319,000	308,000
1979	2,275,000	1,502,000	1,450,000
1989	4,380,000	2,895,000	2,794,000
1999	6,250,000	4,131,000	3,988,000
2009	7,324,000	4,840,000	4,672,000
2019	7,957,000	5,260,000	5,077,000

Local Water Supply

The Delta water facilities would, in addition to conserving water for export, improve the quality of water available to western Delta water users and would make available supplemental water for municipal, industrial, and agricultural use.

Historically the Delta water users have had access to an adequate quantity of water. However, during periods of low flow in the Sacramento and San Joaquin River system the quality of water in the Delta channels has deteriorated because of the incursion of poorer quality water from the San Francisco Bay system. Increasing upstream diversions and exports of water have decreased the percentage of time that good quality water is available in the western Delta channels. This availability of water supply would be further reduced by continued U. S. depletions and by state exports of water from the Delta.

An increased demand for municipal and industrial water has been forecast for the western Delta. Even without state exports of water from the Delta there will not be sufficient water of good quality available in the western Delta channels to satisfy the increased demand.

The Delta water facilities would provide both replacement and supplemental water to the western Delta water users. The replacement water would replace the amount of good quality water which could no longer be obtained from the Delta channels due to the state exports. The supplemental water supply would be water which would not otherwise be available, even without state exports from the Delta. To the extent that the future water requirements exceed the deliverability of existing and presently proposed water supply facilities, sufficient capacity would be provided in the replacement facilities to meet the future supplemental requirements.

The replacement facilities for agricultural water, which are included in the Delta Water Project variations, would be completed in 1965. These facilities would deliver high quality water to approximately 34,000 acres in the western portion of the Delta. The allocated cost of the water quality improvement would be paid by the beneficiaries, probably through a master district. The average annual allocated cost to agricultural water quality during the period 1965 through 2019 would be $1.86 per acre for the Single Purpose and Comprehensive Delta Water Projects.

The Chipps Island Barrier Project would improve the quality of water in the Delta channels and therefore no replacement facilities for agricultural water would be required. The allocated cost to agricultural water quality of the Chipps Island Barrier Project is the same as that for the Single Purpose and Comprehensive Delta Water Projects and, therefore, the average annual cost would be $1.86 per acre during the period 1965 through 2019.

Municipal and industrial water made available to Contra Costa and Solano Counties would consist of both replacement and supplemental water. The average allocated cost to local water supply of the Montezuma Aqueduct deliveries would consist of a transportation cost and a water quality cost. Since Solano County would not receive a water quality benefit, the Solano water users would not pay the water quality charge. Users of supplemental water would pay the Delta Pool price, in addition to the above charges.

Table 81 shows the average annual allocated cost to local water supply and the Delta Pool cost, with each of the four projects.

TABLE 81

AVERAGE COST OF MONTEZUMA AQUEDUCT DELIVERIES

Item	Chipps Island Barrier Project	Single Purpose Delta Water Project	Typical Alternative Delta Water Project	Comprehensive Delta Water Project
Average allocated project[1] cost to local water supply, Contra Costa County (dollars/acre-foot)	3.45	3.45	3.33	3.45
Average allocated project[1] cost to local water supply, Solano County (dollars/acre-foot)	3.21	3.21	3.09	3.21
Delta Pool cost (dollars/acre-foot)[2]	5.61	5.61	5.59	5.61

1/ Sum of average water quality cost plus average transportation cost.
2/ The Delta pool price plus the allocated project cost to local water supply would be the cost of supplemental water. This cost is based upon the equal annual equivalent value between 1970 and 2020.

Flood and Seepage Control

The project costs allocated to flood and seepage control have been sub-allocated between the Federal Government and the local beneficiaries, in keeping with federal policy controlling nonreimbursable flood control allocations.

It has been assumed for the purpose of repayment analysis, that the federal share would be repayed during the construction period. The annual payment would be proportional to the project capital expenditures for flood control in that year. Table 82 shows the estimated schedules of federal flood control contributions for the Typical Alternative and Comprehensive Delta Water Projects.

TABLE 82

ESTIMATED SCHEDULES OF FEDERAL
FLOOD CONTROL CONTRIBUTIONS

Year	Federal contribution	
	Typical Alternative Delta Water Project	Comprehensive Delta Water Project
1963	$ 809,800	$ 1,759,800
1964	392,300	535,700
1965	392,300	516,800
1966	157,000	262,400
1967	157,000	262,400
1968	157,000	468,700
1969	297,000	553,500
1970	436,500	1,154,300
1971	1,628,200	1,867,000
1972	674,500	1,817,000
1973	674,500	2,797,900
1974	1,372,900	1,022,300
1975	588,000	522,700
1976	588,000	553,100
1977	588,400	553,400
1978	588,400	740,900
1979	381,400	459,300
1980	239,700	143,300
TOTALS	$10,122,900	$15,990,500
1960 present worth	6,439,300	10,518,800

The local share of the flood and seepage control allocation would probably be repayed through master districts. The allocated project costs and the average annual cost per acre are presented in Table 83.

TABLE 83

ESTIMATED COST TO LOCAL BENEFICIARIES OF FLOOD AND SEEPAGE CONTROL

Project	Average annual allocated flood and seepage control costs, 1965 through 2019 (dollars)	Area benefited (acres)	Average annual allocated cost per acre 1965-2019 (dollars)
Typical Alternative Delta Water Project	270,800	102,986	2.63
Comprehensive Delta Water Project	693,600	252,258	2.75

Vehicular Transportation

The costs of the Typical Alternative and Comprehensive Delta Water Projects which are allocated to vehicular transportation have been suballocated among the beneficiaries in proportion to the benefits received. Vehicular transportation benefits accrue to local road users, Delta recreationists, and the Counties of Sacramento, San Joaquin, and Contra Costa.

It is expected that in keeping with present legislative policy relating to recreation development, nonreimbursable state funds or gas tax funds willbe available for repayment of the capital cost portion of the allocation to recreation and the annual costs would be repayed from gas tax funds.

Vehicular transportation costs allocated to local beneficiaries would probably be repayed through county taxes.

Repayment schedules based on the above assumptions are presented in Table 84 for the Typical Alternative and Comprehensive Delta Water Projects. These are merely example repayment schedules based on assumed state and local policies and may differ markedly from the actual repayment schedules. No vehicular transportation benefits are provided by the Single Purpose Delta Water or the Chipps Island Barrier Projects, and therefore no costs have been allocated.

TABLE 84

ESTIMATED COST OF VEHICULAR TRANSPORTATION

Typical Alternative Delta Water Project				Comprehensive Delta Water Project		
Allocation to local beneficiaries	Allocated capital cost of recreation access	Allocated annual cost of recreation access	Year	Allocation to local beneficiaries	Allocated capital cost of recreation access	Allocated annual cost of recreation access
	$ 280,700		1963		$ 705,300	
	135,300		1964		487,200	
$ 57,100/year (1965-2019)	135,300		1965	$149,800/year (1965-2019)	470,300	
	54,200		1966		222,300	
	88,000		1967		261,800	
	88,000		1968		631,900	
	143,300		1969		693,800	
	213,000	$ 1,600	1970		751,000	$ 4,700
	820,100	5,200	1971		1,425,500	8,900
	522,100	19,300	1972		1,552,100	25,100
	521,200	19,300	1973		1,406,700	46,200
	1,359,000	19,300	1974		1,910,400	78,000
	1,076,1000	36,200	1975		1,576,700	97,300
	1,076,100	36,200	1976		1,575,800	97,300
	1,076,200	36,200	1977		1,576,500	97,300
	481,000	44,600	1978		695,500	107,500
	149,800	44,600	1979		255,000	162,300
	93,100	105,400	1980		104,100	287,900
		180,000/year (1981-2019)	1981			362,500/year (1981-2019)

Recreation

A portion of the costs of the Typical Alternative and Comprehensive Delta Water Projects has been allocated to recreation. In keeping with the aforementioned policy regarding recreation development, it is expected that the capital costs allocated to recreation would be nonreimbursable and the annual cost would be repaid by the recreationists.

Unassigned Costs

Unassigned costs are those costs which because of the allocation procedure cannot be allocated to any of the project beneficiaries. In the case of the Chipps Island Barrier Project, approximately 75 percent of the total costs cannot be assigned to any beneficiary because alternative plans provide a more economical solution to the water supply problem. Approximately 3 percent of the costs of the Comprehensive Delta Water Project are unassigned because the costs of some flood control features would exceed the resulting benefits.

Summary of Project Repayment

All costs of the Delta water facilities, with the exception of the unassigned costs, would be repayed by the project beneficiaries and which in some cases would take the form of state or federal contributions. The pricing of the project services will be such that during the repayment period the State will recover all project costs except those (such as recreation development) which are nonreimbursable. Tables 85 through 88 present the repayment schedule for each of the alternative Delta facilities.

TABLE 23

FLOOD DAMAGE BY ISLAND-GROUP
DUE TO ONE INUNDATION, UNDER NONPROJECT CONDITIONS

Island-group	Agricultural acreage	Flood damage per acre 1/ in dollars	2/ Island group damage	1960 Frequency of inundation	1960 2/ damage	1980 Frequency of inundation	1980 2/ damage	2000 Frequency of inundation	2000 2/ damage	2020 Frequency of inundation	2020 2/ damage
Isleton	42,760	288.30	12,327.7	.01821	224.5	.0209	257.6	.02325	286.6	.02495	307.6
Lodi	51,735	283.10	14,646.2	.01078	157.9	.01232	180.4	.01377	201.7	.01477	216.3
SUBTOTAL 3/	94,495		26,973.9		382.4		438.0		488.3		523.9
Brentwood	24,792	269.80	6,688.9	.01048	70.1	.01198	80.1	.01338	89.5	.01435	96.0
Holt	90,470	288.00	26,055.4	.00283	73.7	.00323	84.2	.00361	94.1	.00388	101.1
Sherman	9,498	226.50	2,151.3	.021	45.2	.02415	52.0	.0269	57.9	.0288	62.0
Tracy	9,002	297.40	2,677.2	.001	2.7	.00114	3.1	.00128	3.4	.00137	3.7
TOTAL 3/	228,257		64,546.7		574.1		657.4		733.2		786.7

1/ Includes flood damage to crops and cost to reclaim land.
2/ Average annual amount in thousands of dollars.
3/ The Isleton and Lodi island-groups are in the Typical Alternative Delta Water Project, while all island-groups are in the Comprehensive Delta Water Project.

TABLE 31

SUMMARY OF FLOOD AND SEEPAGE CONTROL BENEFITS

(Thousands of dollars)

Island-group	Gross acreage	Benefit due to decreased inundations			Benefit due to reduced cost of flood 1/			Benefit due to reduced cost of: seepage control	Total
		Crop damage	Reclamation costs	Total	Interior levees	Exterior levees	Total		
Isleton	47,313								
1960 present worth		943.1	2,135.8	3,078.9	788.7	1,839.4	2,628.1	464.1	6,171.1
Average annual benefit (construction period, 1963-79)		16.9	38.3	55.2	9.8	72.1	81.9	9.0	146.1
Average annual benefit (full operation, 1980-2019)		81.0	183.4	264.4	72.5	104.7	177.2	39.1	480.7
Lodi	55,673								
1960 present worth		613.1	1,475.8	2,088.9	835.9	2,193.5	3,029.4	692.3	5,810.6
Average annual benefit (construction period, 1963-80)		10.9	26.4	37.3	12.7	104.5	117.2	21.0	175.5
Average annual benefit (full operation, 1981-2019)		52.7	126.8	179.5	74.3	117.2	191.5	50.1	421.1
Subtotal 2/	102,986								
1960 present worth		1,556.2	3,611.6	5,167.8	1,624.6	4,032.9	5,657.5	1,156.4	11,981.7
Average annual benefit (construction period)		27.8	64.7	92.5	22.5	176.6	199.1	30.0	321.6
Average annual benefit (full operation)		133.7	310.2	443.9	146.8	221.9	368.7	89.2	901.8
Holt	96,652								
1960 present worth		231.1	525.3	756.4	913.2	3,568.3	4,481.5	996.1	6,234.0
Average annual benefit (construction period, 1963-79)		4.3	9.8	14.1	2.8	161.4	164.2	24.6	202.9
Average annual benefit (full operation, 1980-2019)		18.9	43.1	62.0	88.9	198.2	287.1	75.7	424.8
Tracy	9,886								
1960 present worth		1.5	3.0	4.5	52.2	451.2	503.4	61.5	569.4
Average annual benefit (construction period, 1963-73)		0.0	0.1	0.1	0.6	13.3	13.9	0.0	14.0
Average annual benefit (full operation, 1974-2019)		0.1	0.2	0.3	3.8	35.3	39.1	4.9	44.3
Brentwood	32,284								
1960 present worth		249.4	714.7	964.1	299.6	1,397.3	1,696.9	339.1	3,000.1
Average annual benefit (construction period, 1963-78)		4.7	13.3	18.0	4.6	68.8	73.4	9.7	101.1
Average annual benefit (full operation, 1979-2019)		20.4	58.6	79.0	25.5	72.1	97.6	24.4	201.0
Sherman	10,450								
1960 present worth		86.2	650.2	736.4	0.0	597.4	597.4	0.0	1,333.8
Average annual benefit (construction period, 1963-78)		2.6	19.4	22.0	0.0	17.3	17.3	0.0	39.3
Average annual benefit (full operation, 1979-2019)		6.3	47.4	53.7	0.0	45.4	45.4	0.0	99.1
Total 3/	252,258								
1960 present worth		2,124.4	5,504.8	7,629.2	2,889.6	10,047.1	12,936.7	2,553.1	23,119.0
Average annual benefit (construction period)		39.4	107.3	146.7	30.5	437.4	467.9	64.3	678.9
Average annual benefit (full operation)		179.4	459.5	638.9	265.0	572.9	837.9	194.2	1,671.0

1/ Includes benefits due to reduced maintenance and flood fighting costs.
2/ Typical Alternative Delta Water Project.
3/ Comprehensive Delta Water Project.

TABLE 85

REPAYMENT SCHEDULE--CHIPPS ISLAND BARRIER PROJECT
(In thousands of dollars)

Year	Costs: Capital	Costs: Operation, maintenance, and replacement	Costs: Power, navigation locks	Costs: Interest on outstanding investment	Costs: Total	Revenues: Water salvage	Revenues: Supplemental water: Contra Costa County	Revenues: Supplemental water: Solano County	Revenues: Water quality: Municipal and industrial	Revenues: Water quality: Agricultural	Revenues: Unassigned costs	Revenues: Total	Outstanding investment
1963	2,087				2,087.0	26.4						[illegible]	2,060.6
1964	28,148			82.4	28,230.4	59.5						59.5	30,231.5
1965	27,635	19.4		1,209.3	28,863.7	92.5				62.7	2,243.2	2,398.4	56,696.8
1966	22,552	37.2		2,267.9	24,857.1	125.6				62.7	2,577.5	2,765.8	78,788.4
1967	34,879.	114.8		3,151.5	38,145.3	189.7				62.7	2,911.9	3,164.3	113,769.1
1968	39,249	114.8		4,550.8	43,914.6	254.5				62.7	3,246.3	3,563.5	154,120.2
1969	39,327	114.8		6,164.8	45,606.6	318.6				62.7	3,580.7	3,962.0	195,864.8
1970	1,424	2,768.2	28.8	7,830.6	12,051.6	383.4			51.8	62.7	3,915.1	4,413.0	203,403.4
1971	763	2,772.6	30.0	8,136.1	11,701.7	507.6	16.4		58.0	62.7	4,249.5	4,894.2	210,210.9
1972	5,908	2,772.6	31.2	8,408.4	17,120.2	631.9	32.8		64.1	62.7	4,583.9	5,375.4	221,955.7
1973		3,085.7	32.4	8,878.2	11,996.3	756.2	49.1		70.2	62.7	4,918.3	5,856.5	228,095.5
1974		3,085.7	33.6	9,123.8	12,243.1	880.5	65.5		76.4	62.7	5,252.7	6,337.8	234,000.8
1975		3,085.7	34.8	9,360.0	12,480.5	1,004.7	81.9		82.6	62.7	5,587.0	6,818.9	239,662.4
1976		3,085.7	36.0	9,586.5	12,708.2	1,129.0	98.3		88.8	62.7	5,921.4	7,300.2	245,070.4
1977		3,085.7	37.2	9,802.8	12,925.7	1,253.3	114.6		95.0	62.7	6,255.8	7,781.4	250,214.7
1978		3,085.7	38.4	10,008.6	13,132.7	1,377.5	131.0		101.1	62.7	6,590.2	8,262.5	255,084.9
1979		3,085.7	39.6	10,203.4	13,328.7	1,502.5	147.4		107.2	62.7	6,924.6	8,744.4	259,669.2
1980		3,085.7	40.8	10,386.8	13,513.3	1,627.4	163.8		113.4	62.7	7,259.0	9,226.3	263,956.2
1981		3,085.7	42.0	10,558.2	13,685.9	1,752.3	176.0	.5	120.6	62.7	7,593.4	9,705.5	267,936.6
1982		3,085.7	43.2	10,717.5	13,846.4	1,877.2	188.3	1.0	127.8	62.7	7,927.8	10,184.8	271,598.2
1983		3,085.7	44.4	10,863.9	13,994.0	2,022.7	200.6	1.4	134.9	62.7	8,262.2	10,684.5	274,907.7
1984		3,085.7	45.6	10,996.3	14,127.6	2,168.1	212.9	1.9	142.1	62.7	8,596.6	11,184.3	277,851.0
1985		3,085.7	46.8	11,114.0	14,246.5	2,313.5	225.2	2.4	149.3	62.7	8,931.0	11,684.1	280,413.4
1986		3,085.7	48.0	11,216.5	14,350.2	2,458.9	237.4	2.9	156.5	62.7	9,265.3	12,183.7	282,579.9
1987		3,085.7	49.2	11,303.2	14,438.1	2,604.3	249.7	3.4	163.7	62.7	9,599.7	12,683.5	284,334.5
1988		3,085.7	50.4	11,373.4	14,509.5	2,749.8	262.0	3.9	170.8	62.7	9,934.1	13,183.3	285,660.7
1989		3,085.7	51.6	11,426.4	14,563.7	2,895.2	274.3	4.3	178.0	62.7	10,268.5	13,683.0	286,541.4
1990		3,085.7	52.8	11,461.6	14,600.1	3,040.6	286.5	4.8	185.2	62.7	10,602.9	14,182.7	286,958.8
1991		3,085.7	54.0	11,478.4	14,618.1	3,174.8	299.8	10.1	193.2	62.7	10,937.3	14,677.9	286,899.0
1992		3,085.7	55.2	11,476.0	14,616.9	3,309.0	313.1	15.4	201.1	62.7	11,271.7	15,173.0	286,342.9
1993		3,085.7	56.4	11,453.7	14,595.8	3,443.1	326.5	20.7	209.2	62.7	11,606.1	15,668.3	285,270.4
1994		3,085.7	57.6	11,410.8	14,554.1	3,577.3	339.8	26.0	217.1	62.7	11,940.5	16,163.4	283,661.1
1995		3,085.7	58.8	11,346.4	14,490.9	3,712.2	353.1	31.3	225.1	62.7	12,274.8	16,659.2	281,492.8
1996		3,085.7	60.0	11,259.7	14,405.4	3,847.0	366.4	36.6	233.1	62.7	12,609.2	17,155.0	278,743.2
1997		3,085.7	61.2	11,149.7	14,296.6	3,949.5	379.7	41.9	241.0	62.7	12,943.6	17,618.4	275,421.4
1998		3,085.7	62.4	11,016.9	14,165.0	4,051.9	393.0	47.2	249.1	62.7	13,278.0	18,081.9	271,504.5
1999		3,085.7	63.6	10,860.2	14,009.5	4,131.2	406.3	52.5	257.0	62.7	13,612.4	18,522.1	266,991.9
2000		3,085.7	64.8	10,679.7	13,830.2	4,210.6	419.6	57.8	265.0	62.7	13,946.8	18,962.5	261,859.6
2001		3,085.7	66.0	10,474.4	13,626.1	4,289.9	431.5	69.7	275.7	62.7	14,281.2	19,410.7	256,095.0
2002		3,085.7	67.2	10,243.0	13,395.9	4,369.2	443.4	81.5	286.4	62.7	14,615.6	19,858.8	249,612.1
2003		3,085.7	68.4	9,984.5	13,138.6	4,448.5	455.4	93.4	297.1	62.7	14,950.0	20,307.1	242,443.6
2004		3,085.7	69.6	9,697.7	12,853.0	4,527.8	467.3	105.3	307.8	62.7	15,284.4	20,755.3	234,541.3
2005		3,085.7	70.8	9,381.7	12,538.2	4,607.2	479.2	117.2	318.5	62.7	15,618.8	21,203.6	225,875.9
2006		3,085.7	72.0	9,035.0	12,192.7	4,665.3	491.1	129.0	329.2	62.7	15,953.1	21,630.4	216,438.2
2007		3,085.7	73.2	8,657.5	11,816.4	4,723.5	503.0	140.9	339.9	62.7	16,287.5	22,057.5	206,197.1
2008		3,085.7	74.4	8,247.9	11,408.0	4,781.7	514.9	152.8	350.7	62.7	16,621.9	22,484.7	195,120.4
2009		3,085.7	75.6	7,804.8	10,966.1	4,840.5	526.8	164.7	361.3	62.7	16,956.3	22,912.3	183,174.2
2010		3,085.7	76.8	7,3[illegible]	10,489.5	4,899.3	538.7	176.6	372.0	62.7	17,290.7	23,340.0	170,323.7
2011		3,085.7	78.0	6,812.9	9,976.6	4,958.2	549.7	200.7	383.9	62.7	17,625.1	23,780.3	156,520.0
2012		3,085.7	79.2	6,260.8	9,425.7	5,017.0	560.6	224.8	395.7	62.7	17,959.5	24,220.3	141,725.4
2013		3,085.7	80.4	5,669.0	8,835.1	5,051.4	571.5	248.9	407.5	62.7	18,293.9	24,635.9	125,924.6
2014		3,085.7	81.6	5,037.0	8,204.3	5,085.7	582.4	273.0	419.3	62.7	18,628.3	25,051.4	109,077.5
2015		3,085.7	82.8	4,363.1	7,531.6	5,120.1	593.3	297.1	431.1	62.7	18,962.6	25,466.9	[illegible]
2016		3,085.7	84.0	3,645.7	6,815.4	5,154.5	604.2	321.2	443.0	62.7	19,297.0	25,882.6	72,075.0
2017		3,085.7	85.2	2,883.0	6,053.9	5,189.5	615.1	345.3	454.8	62.7	19,631.4	26,298.8	51,830.1
2018		3,085.7	86.4	2,073.2	5,245.3	5,224.5	626.0	369.4	466.6	62.7	19,965.8	26,715.0	30,360.4
2019		3,085.7	87.6	1,214.4	4,387.7	5,259.6	636.9	393.5	478.4	62.7	20,300.2	27,131.3	7,616.8

TABLE 86

REPAYMENT SCHEDULE--SINGLE PURPOSE DELTA WATER PROJECT
(Thousands of dollars)

Year	Costs: Capital	Costs: Operation, maintenance, & replacement	Costs: Montezuma Aqueduct power	Costs: Interest on outstanding investment	Costs: Total	Revenues: Water salvage	Revenues: Supplemental water: Contra Costa County	Revenues: Supplemental water: Solano County	Revenues: Water quality: Municipal & industrial	Revenues: Water quality: Agricultural	Revenues: Total	Outstanding investment
1963	2,141				2,141.0	26.4					26.4	2,114.6
1964	2,292			84.6	2,376.6	59.5					59.5	4,431.7
1965		176.2		177.3	353.5	92.5				62.7	155.2	4,630.0
1966		176.2		185.2	361.4	125.6				62.7	188.3	4,803.1
1967		176.2		192.1	368.3	189.7				62.7	252.4	4,919.0
1968	9,324	176.2		196.8	9,697.0	254.5				62.7	317.2	14,298.8
1969	9,325	176.2		572.0	10,073.2	318.6				62.7	381.3	23,990.7
1970	6,953	445.1		959.6	7,457.7	383.4			51.8	62.7	497.9	30,950.5
1971	593	644.9	9.8	1,238.0	2,485.7	507.6	16.4		58.0	62.7	644.7	32,791.5
1972		644.1	19.6	1,311.7	1,995.4	631.9	32.8		64.1	62.7	791.5	33,995.4
1973	2,355	664.1	29.5	1,359.8	4,408.4	756.2	49.1		70.2	62.7	938.2	37,465.6
1974	4,291	664.1	39.3	1,498.6	6,493.0	880.5	65.5		76.4	62.7	1,085.1	42,873.5
1975	2,046	748.5	49.1	1,714.9	4,558.5	1,004.7	81.9		82,6	62.7	1,231.9	46,200.1
1976	2,729	751.8	58.9	1,848.0	5,387.7	1,129.0	98.3		88.8	62.7	1,378.8	50,209.0
1977	2,729	751.8	68.7	2,008.4	5,557.9	1,253.3	114.6		95.0	62.7	1,525.6	54,241.3
1978		798.4	78.6	2,169.7	3,046.7	1,377.5	131.0		101.1	62.7	1,672.3	55,615.7
1979		798.4	88.4	2,224.6	3,111.4	1,502.5	147.4		107.2	62.7	1,819.8	56,907.3
1980	1,781	801.0	98.2	2,276.3	4,956.5	1,627.4	163.8		113.4	62.7	1,967.3	59,896.5
1981	612	801.0	109.2	2,395.9	3,918.1	1,752.3	176.0	.5	120.6	62.7	2,112.1	61,702.5
1982		845.9	120.3	2,468.1	3,434.3	1,877.2	188.3	1.0	127.8	62.7	2,257.0	62,879.8
1983		845.9	131.3	2,515.2	3,492.4	2,022.7	200.6	1.4	134.9	62.7	2,422.3	63.949.9
1984		845.9	142.4	2,558.0	3,546.3	2,168.1	212.9	1.9	142.1	62.7	2,587.7	64,908.5
1985		845.9	153.5	2,596.3	3,595.7	2,313.5	225.2	2.4	149.3	62.7	2,753.1	65,751.1
1986		845.9	164.5	2,630.0	3,640.4	2,458.9	237.4	2.9	156.5	62.7	2,918.4	66,473.1
1987		845.9	175.6	2,658.9	3,680.4	2,604.3	249.7	3.4	163.7	62.7	3,083.8	67,069.7
1988		845.9	186.6	2,682.8	3,715.3	2,749.8	262.0	3.9	170.8	62.7	3,249.2	67.535.8
1989		845.9	197.7	2,701.4	3,745.0	2,895.2	274.3	4.3	178.0	62.7	3,414.5	67,866.3
1990		845.9	208.7	2,714.7	3,769.3	3,040.6	286.5	4.8	185.2	62.7	3,579.8	68,055.8
1991		845.9	224.8	2,722.2	3,792.9	3,174.8	299.8	10.1	193.2	62.7	3,740.6	68,108.1
1992		845.9	240.9	2,724.3	3,811.1	3,309.0	313.1	15.4	201.1	62.7	3,901.3	68,017.9
1993		845.9	257.1	2,720.7	3,823.7	3,443.1	326.5	20.7	209.2	62.7	4,062.2	67,779.4
1994		845.9	273.2	2,711.2	3,830.3	3,577.3	339.8	26.0	217.1	62.7	4,222.9	67,386.8
1995	105	847.1	289.3	2,695.5	3,936.9	3,712.2	353.1	31.3	225.1	62.7	4,384.4	66,939.3
1996		847.1	305.4	2,677.6	3,830.1	3,847.0	366.4	36.6	233.1	62.7	4,545.8	66,223.6
1997		847.1	321.5	2,648.9	3,817.5	3,949.5	379.7	41.9	241.0	62.7	4,674.8	65,366.3
1998		847.1	337.6	2,614.7	3,799.4	4,051.9	393.0	47.2	249.1	62.7	4,803.9	64,361.8
1999		847.1	353.7	2,574.5	3,775.3	4,131.2	406.3	52.5	257.0	62.7	4,909.7	63,227.4
2000		847.1	369.8	2,529.1	3,746.0	4,210.6	419.6	57.8	265.0	62.7	5,015.7	61,957.7
2001		847.1	387.9	2,478.3	3,713.3	4,289.9	431.5	69.7	275.7	62.7	5,129.5	60,541.3
2002		847.1	405.9	2,421.7	3,674.7	4,369.2	443.4	81.5	286.4	62.7	5,243.2	58,973.0
2003		847.1	424.0	2,358.9	3,630.0	4,448.5	455.4	93.4	297.1	62.7	5,357.1	57,245.9
2004		847.1	442.0	2,289.8	3,578.9	4,527.8	467.3	105.3	307.8	62.7	5,470.9	55,353.9
2005		847.1	460.0	2,214.2	3,521.3	4,607.2	479.2	117.2	318.5	62.7	5,584.8	53,290.4
2006		847.1	478.1	2,131.6	3,436.8	4,665.3	491.1	129.0	329.2	62.7	5,677.3	51,069.9
2007		847.1	496.1	2,042.8	3,386.0	4,723.5	503.0	140.9	339.9	62.7	5,770.0	48,685.9
2008		847.1	514.2	1,947.4	3,308.7	4,781.7	914.9	152.8	350.7	62.7	5,862.8	46,131.8
2009		847.1	532.2	1,845.3	3,224.6	4,840.5	526.8	164.7	361.3	62.7	5,956.0	43,400.4
2010	179	849.1	550.2	1,736.0	3,314.3	4,899.3	538.7	176.6	372.0	62.7	6,049,3	40,665.4
2011		849.1	566.2	1,626.6	3,041.9	4,958.2	549.7	200.7	383.9	62.7	6,155.2	37,552.1
2012		849.1	582.2	1,502.1	2,933.4	5,017.0	560.6	224.8	395.7	62.7	6,260.8	34,224.7
2013		849.1	598.2	1,369.0	2,816.3	5,051.4	571.5	248.9	407.5	62.7	6,342.0	30,699.0
2014		849.1	614.3	1,228.0	2,691.4	5,085.7	582.4	273.0	419.3	62.7	6,423.1	26,967.3
2015		849.1	630.3	1,078.7	2,558.1	5,120.1	593.3	297.1	431.1	62.7	6,504.3	23,021.1
2016		849.1	646.3	920.8	2,416.2	5,154.5	604.2	321.2	443.0	62.7	6,585.6	18,851.7
2017		849.1	662.3	754.1	2,265.5	5,189.5	615.1	345.3	454.8	62.7	6,667.4	[illegible]
2018		849.1	678.3	578.0	2,105.4	5,224.5	626.0	369.4	466.6	62.7	6,749.2	9,806.0
2019		849.1	694.3	392.2	1,935.6	5,259.6	636.9	393.5	478.4	62.7	6,831.1	4,910.5

TABLE 87

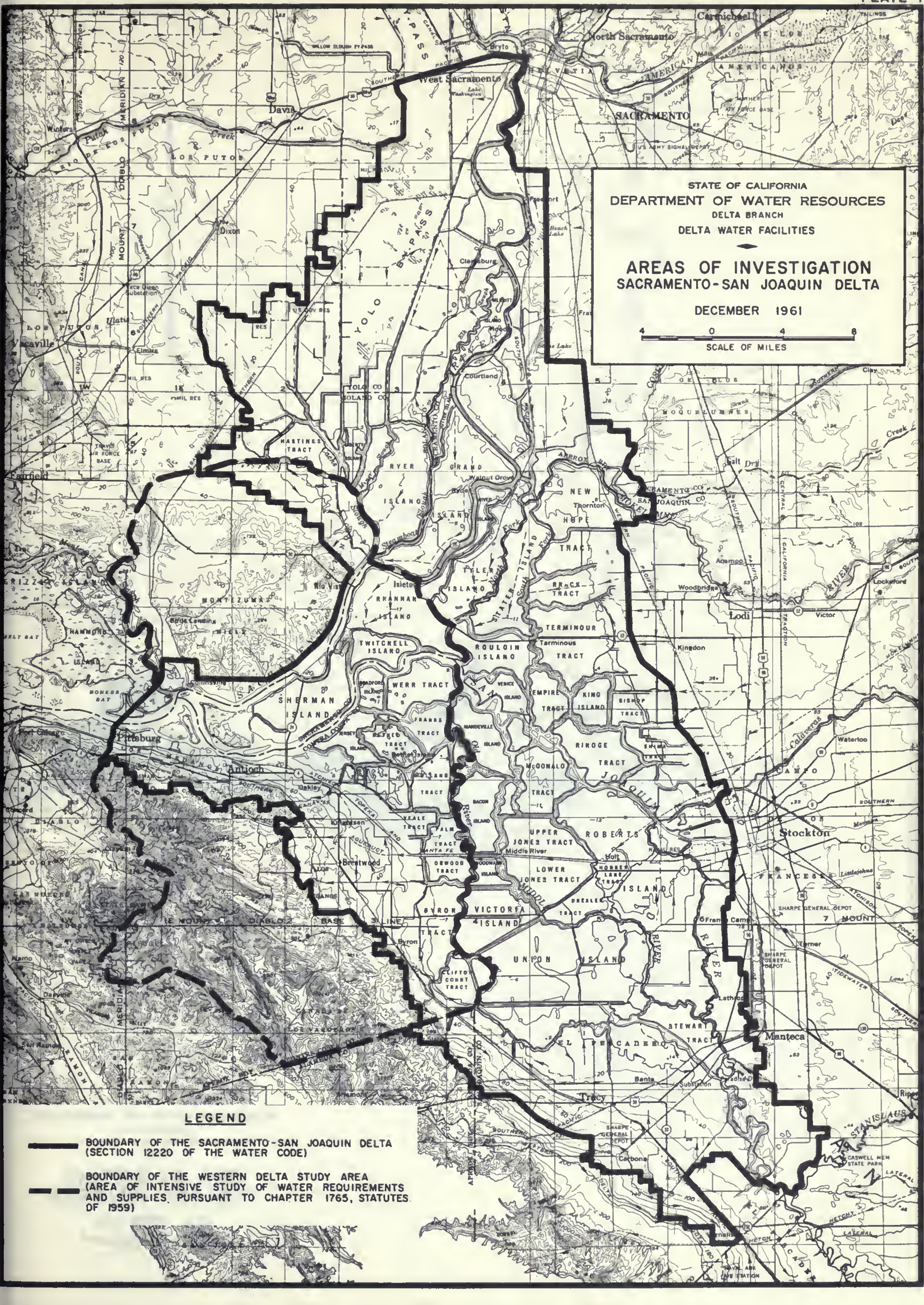
REPAYMENT SCHEDULE--TYPICAL ALTERNATIVE DELTA WATER PROJECT
(In thousands of dollars)

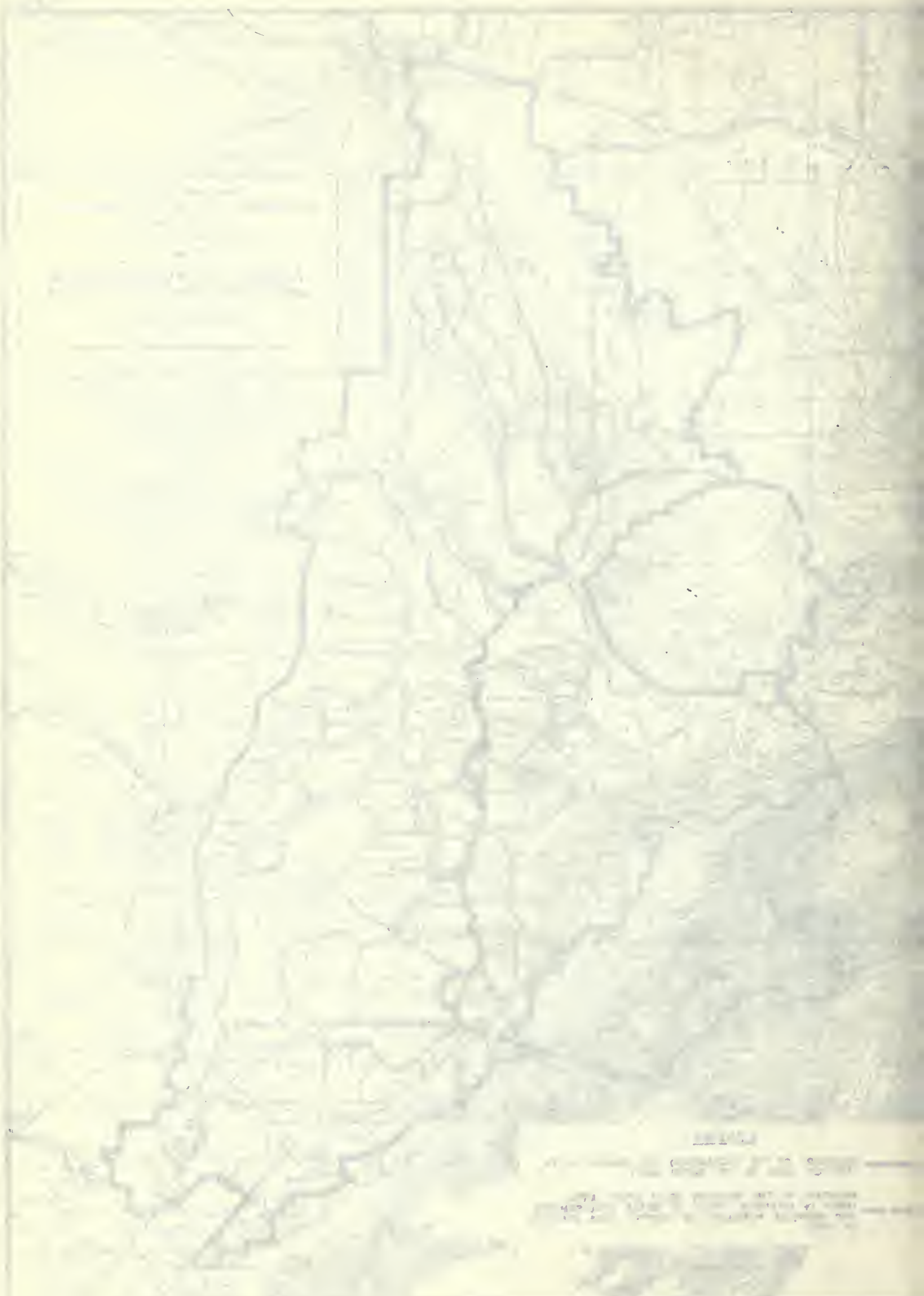
	Costs					Revenues														
							Supplemental water:		Water quality		Flood & Seepage: control		Vehicular transportation							
														Recreation access		Recreation				
Year	Capital	Operation, maintenance, and replacement	Montezuma Aqueduct power	Interest on: outstanding: investment	Total	Water salvage	Contra Costa County	Solano County	Municipal and industrial	Agricultural	Federal	Local	Local	Capital	Annual	Capital	Annual	Total	Outstanding investment
1963	3,852				3,852.0	85.5					809.8			280.7		41.6		1,157.6	2,694.4
1964	3,101			107.8	3,208.8	57.4					392.3			135.3		20.1		605.1	5,298.1
1965	827	175.2		211.9	1,214.1	89.3				60.5	392.3	270.8	57.1	135.3		20.1		1,025.4	5,486.8
1966	331	175.2		219.5	725.7	121.2				60.5	157.0	270.8	57.1	54.2		8.0		728.8	5,483.7
1967	2,438	175.2		219.3	2,832.5	183.1				60.5	157.0	270.8	57.1	88.0		13.0		829.5	7,486.7
1968	9,878	175.2		299.5	10,352.7	245.6				60.5	157.0	270.8	57.1	88.0		13.0		892.0	16,947.4
1969	10,197	175.2		677.9	11,050.1	307.5				60.5	297.0	270.8	57.1	143.3		21.2		1,157.4	26,840.1
1970	5,187	454.7		1,073.6	6,715.3	370.0			49.9	60.5	436.5	270.8	57.1	213.0	1.6	24.3	.2	1,483.9	32,071.5
1971	3,646	674.3	9.8	1,282.9	5,613.0	490.0	15.8		55.9	60.5	1,628.2	270.8	57.1	820.1	5.2	76.5	.7	3,480.8	24,203.7
1972	1,756	761.5	19.6	1,368.1	3,905.2	609.9	31.6		61.8	60.5	674.5	270.8	57.1	522.1	19.3	34.5	2.7	2,344.8	35,764.1
1973	3,135	761.5	29.5	1,430.6	5,356.6	729.9	47.4		67.7	60.5	674.5	270.8	57.1	521.2	19.3	34.5	2.7	2,485.6	38,635.1
1974	6,481	761.5	39.3	1,545.4	8,827.2	849.8	63.2		73.7	60.5	1,372.9	270.8	57.1	1,359.0	19.3	163.4	2.7	4,292.4	43,169.9
1975	4,628	890.4	49.1	1,726.8	7,294.3	969.8	79.0		79.6	60.5	588.0	270.8	57.1	1,026.1	36.2	118.5	4.9	3,340.5	47,123.7
1976	4,370	893.7	58.9	1,884.9	7,207.5	1,089.7	94.7		85.6	60.5	588.0	270.8	57.1	1,076.1	36.2	118.5	4.9	3,482.1	50,849.1
1977	3,372	953.5	68.7	2,034.0	6,428.2	1,209.6	110.5		91.5	60.5	588.4	270.8	57.1	1,076.2	36.2	118.6	4.9	3,624.3	53.653.0
1978	1,566	977.8	78.6	2,146.1	4,768.5	1,329.6	126.3		97.4	60.5	588.4	270.8	57.1	481.0	44.6	30.4	6.1	3,092.2	55,329.3
1979	817	977.8	88.4	2,213.2	4,096.4	1,450.2	142.1		103.4	60.5	381.4	270.8	57.1	149.8	44.6	18.9	6.1	2,684.9	56,740.8
1980	1,666	1,129.4	98.2	2,269.6	5,163.2	1,570.8	157.9		109.3	60.5	239.7	270.8	57.1	93.1	105.4	10.6	8.6	2,683.8	59,220.2
1981		1,264.8	109.2	2,368.8	3,742.8	1,694.3	169.7	.5	16.2	60.5		270.8	57.1		180.0		10.6	2,556.7	60,406.3
1982		1,264.8	120.3	2,416.3	3,801.4	1,811.9	181.6	.9	23.1	60.5		270.8	57.1		180.0		10.6	2,696.5	61,511.2
1983		1,264.8	131.3	2,460.4	3,856.5	1,952.3	193.4	1.4	30.0	60.5		270.8	57.1		180.0		10.6	2,856.1	62,511.6
1984		1,264.8	142.4	2,500.5	3,907.7	2,092.6	205.2	1.9	137.0	60.5		270.8	57.1		180.0		10.6	3,015.7	63,403.6
1985		1,264.8	153.5	2,536.1	3,954.4	2,233.0	217.0	2.3	143.9	60.5		270.8	57.1		180.0		10.6	3,175.2	64,182.8
1986		1,264.8	164.5	2,567.3	3,996.6	2,373.4	228.9	2.8	150.8	60.5		270.8	57.1		180.0		10.6	3,334.9	64,844.5
1987		1,264.8	175.6	2,593.8	4,034.2	2,513.7	240.8	3.2	157.8	60.5		270.8	57.1		180.0		10.6	3,494.5	65,384.2
1988		1,264.8	186.6	2,615.4	4,066.8	2,654.1	252.6	3.7	164.7	60.5		270.8	57.1		180.0		10.6	3,654.1	65,796.9
1989		1,264.8	197.7	2,631.9	4,094.4	2,794.4	264.4	4.2	171.6	60.5		270.8	57.1		180.0		10.6	3,813.6	66,077.7
1990		1,264.8	208.7	2,643.1	4,116.6	2,934.8	276.3	4.6	178.5	60.5		270.8	57.1		180.0		10.6	3,973.2	66,221.1
1991		1,264.8	224.8	2,648.8	4,138.4	3,064.3	289.1	9.7	186.2	60.5		270.8	57.1		180.0		10.6	4,128.3	66,231.2
1992		1,264.8	240.9	2,649.2	4,154.9	3,193.8	301.9	14.8	193.9	60.5		270.8	57.1		180.0		10.6	4,283.4	66,102.7
1993		1,264.8	257.1	2,644.1	4,166.0	3,323.3	314.8	19.9	201.6	60.5		270.8	57.1		180.0		10.6	4,438.6	65,830.1
1994		1,264.8	273.2	2,633.2	4,171.2	3,452.9	327.6	25.0	209.3	60.5		270.8	57.1		180.0		10.6	4,593.8	65,407.5
1995	105	1,266.0	289.3	2,616.3	4,276.6	3,583.0	340.4	30.1	217.0	60.5		270.8	57.1		180.0		10.6	4,749.5	64,934.6
1996		1,266.0	305.4	2,597.4	4,168.8	3,713.2	353.2	35.2	224.6	60.5		270.8	57.1		180.0		10.6	4,905.2	64,198.2
1997		1,266.0	321.5	2,567.9	4,155.4	3,812.0	366.1	40.3	232.3	60.5		270.8	57.1		180.0		10.6	5,029.7	63,323.9
1998		1,266.0	337.6	2,533.0	4,136.6	3,910.9	378.9	45.4	240.1	60.5		270.8	57.1		180.0		10.6	5,154.3	62,306.2
1999		1,266.0	353.7	2,492.2	4,111.9	3,987.5	391.7	50.5	247.7	60.5		270.8	57.1		180.0		10.6	5,256.4	61,161.7
2000		1,266.0	369.8	2,446.5	4,082.3	4,064.1	404.6	55.6	255.4	60.5		270.8	57.1		180.0		10.6	5,358.7	59,885.3
2001		1,266.0	387.9	2,395.4	4,049.3	4,140.6	416.1	67.0	265.8	60.5		270.8	57.1		180.0		10.6	5,468.4	58,466.2
2002		1,266.0	405.9	2,338.6	4,010.5	4,217.2	427.5	78.5	276.0	60.5		270.8	57.1		180.0		10.6	5,578.2	56,898.5
2003		1,266.0	424.0	2,275.9	3,965.9	4,293.7	439.0	89.9	286.4	60.5		270.8	57.1		180.0		10.6	5,688.0	55,176.4
2004		1,266.0	442.0	2,207.1	3,915.1	4,370.3	450.5	101.4	296.7	60.5		270.8	57.1		180.0		10.6	5,797.9	53,293.6
2005		1,266.0	460.0	2,131.7	3,857.7	4,446.9	462.0	112.8	307.0	60.5		270.8	57.1		180.0		10.6	5,897.7	51,243.6
2006		1,266.0	478.1	2,049.7	3,793.8	4,503.0	473.5	124.2	317.3	60.5		270.8	57.1		180.0		10.6	5,997.0	49,040.4
2007		1,266.0	496.1	1,961.6	3,723.7	4,559.1	485.0	135.6	327.6	60.5		270.8	57.1		180.0		10.6	6,086.3	46,677.8
2008		1,266.0	514.2	1,867.1	3,647.3	4,615.3	496.5	147.1	338.0	60.5		270.8	57.1		180.0		10.6	6,175.9	44,149.2
2009		1,266.0	532.2	1,766.0	3,564.2	4,672.1	508.0	158.5	348.3	60.5		270.8	57.1		180.0		10.6	6,265.9	41,447.5
2010	178	1,268.0	550.2	1,657.9	3,654.1	4,728.9	519.4	170.0	358.6	60.5		270.8	57.1		180.0		10.6	6,355.9	38,745.7
2011		1,268.0	566.2	1,549.8	3,384.0	4,785.6	530.0	193.2	370.0	60.5		270.8	57.1		180.0		10.6	6,457.8	35,671.9
2012		1,268.0	582.2	1,426.9	3,277.1	4,842.4	540.5	216.4	381.4	60.5		270.8	57.1		180.0		10.6	6,559.7	32,389.3
2013		1,268.0	598.2	1,295.6	3,161.8	4,875.6	551.0	239.6	392.8	60.5		270.8	57.1		180.0		10.6	6,638.0	28,913.1
2014		1,268.0	614.3	1,156.5	3,038.8	4,908.8	561.5	262.8	404.2	60.5		270.8	57.1		180.0		10.6	6,716.3	25,235.6
2015		1,268.0	630.3	1,009.4	2,907.7	4,941.9	572.0	286.0	415.6	60.5		270.8	57.1		180.0		10.6	6,794.5	21,348.8
2016		1,268.0	646.3	854.0	2,768.3	4,975.1	582.5	309.2	426.9	60.5		270.8	57.1		180.0		10.6	6,872.7	17,244.4
2017		1,268.0	662.3	689.8	2,620.1	5,008.9	593.1	332.4	438.3	60.5		270.8	57.1		180.0		10.6	6,951.7	12,912.8
2018		1,268.0	678.3	516.5	2,462.8	5,042.8	603.6	355.6	449.7	60.5		270.8	57.1		180.0		10.6	7,030.7	8,344.9
2019		1,268.0	694.3	333.8	2,296.1	5,076.6	614.1	378.8	461.1	60.5		270.8	57.1		180.0		10.6	7,109.6	3,531.4

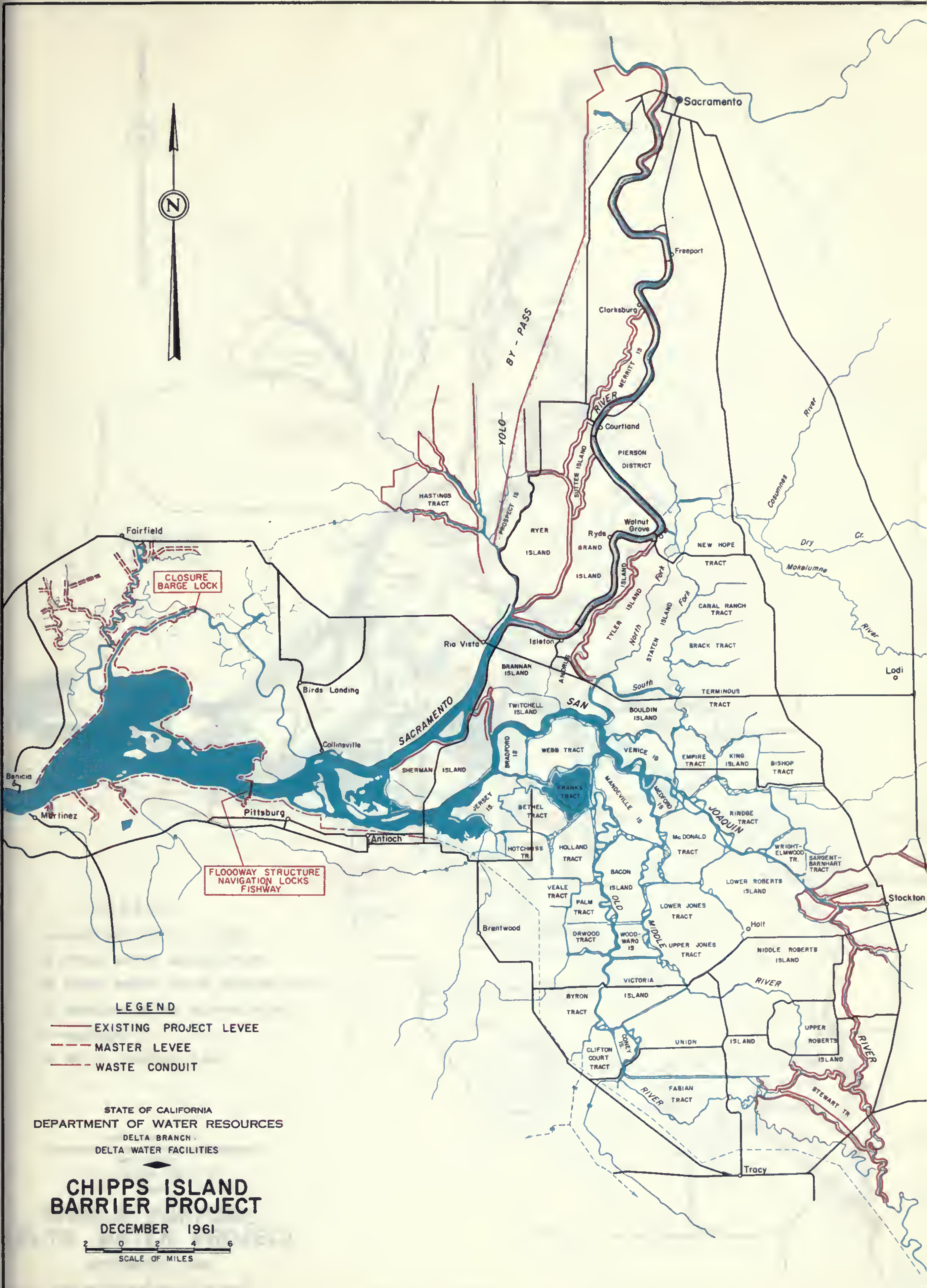
TABLE 88

REPAYMENT SCHEDULE--COMPREHENSIVE DELTA WATER PROJECT
(In thousands of dollars)

Year	Costs: Capital	Costs: Operation, maintenance, and replacement	Costs: Montezuma Aqueduct power	Costs: Interest on outstanding investment	Costs: Total	Revenues: Water salvage	Revenues: Supplemental water: Contra Costa County	Revenues: Supplemental water: Solano County	Revenues: Water quality: Municipal and industrial	Revenues: Water quality: Agricultural	Revenues: Flood & Seepage control: Federal	Revenues: Flood & Seepage control: Local	Revenues: Vehicular transportation: Local	Revenues: Vehicular transportation: Recreation access: Capital	Revenues: Vehicular transportation: Recreation access: Annual	Revenues: Recreation: Capital	Revenues: Recreation: Annual	Revenues: Unassigned costs	Revenues: Total	Outstanding investment
1963	6,218				6,218.0	26.4					1,7[illegible].8			705.3		106.5			2,598.0	3,620.0
1964	3,381			144.8	3,525.8	59.5					535.7			487.2		48.8			1,131.2	6,014.6
1965	1,909	125.1		240.6	2,274.7	92.5				62.7	516.8	693.6	149.8	470.3		46.1		149.0	2,180.8	6,108.5
1966	924	125.1		244.3	1,293.4	125.6				62.7	262.4	693.6	149.8	222.3		20.7		149.0	1,686.1	5,715.8
1967	3,031	125.1		228.6	3,384.7	189.7				62.7	262.4	693.6	149.8	261.8		26.6		149.0	1,795.6	7,304.9
1968	11,635	[illegible].1		292.2	12,052.3	254.5				62.7	468.7	693.6	149.8	631.9		58.6		149.0	2,468.8	16,888.4
1969	11,955	125.1		675.5	12,755.6	318.6				62.7	553.5	693.6	149.8	693.8		68.4		149.0	2,689.4	26,954.6
1970	7,766	410.7		1,078.2	9,254.9	383.4			51.8	62.7	1,154.3	693.6	149.8	751.0	4.7	70.0	.7	149.0	3,471.0	32,738.5
1971	6,305	630.3	9.8	1,309.5	8,254.6	507.6	16.4		58.0	62.7	1,867.0	693.6	149.8	1,425.5	8.9	134.6	1.3	149.0	5,074.4	35,918.7
1972	6,533	716.9	19.6	1,436.7	8,706.2	631.9	32.8		64.1	62.7	1,817.0	693.6	149.8	1,552.1	25.1	155.9	3.6	149.0	5,337.6	39,287.3
1973	9,254	814.6	29.5	1,571.5	11,669.6	756.2	49.1		70.2	62.7	2,797.9	693.6	149.8	1,406.7	46.2	131.7	6.7	149.0	6,319.8	44,637.1
1974	7,494	1,011.1	39.3	1,785.5	10,329.9	880.5	65.5		76.4	62.7	1,022.3	693.6	149.8	1,910.4	78.0	218.8	8.8	149.0	5,315.8	49,651.2
1975	5,641	1,1[illegible]	49.1	1,986.0	8,816.1	1,004.7	81.9		82.6	62.7	552.7	693.6	149.8	1,576.7	97.3	165.5	11.4	149.0	4,627.9	53,839.4
1976	5,383	1,143.3	58.9	2,153.6	8,738.8	1,129.0	98.3		88.8	62.7	1,553.1	693.6	149.8	1,575.8	97.3	165.6	11.4	149.0	4,774.4	57,803.8
1977	4,386	1,203.1	68.7	2,312.2	7,970.0	1,253.3	114.6		95.0	62.7	553.4	693.6	149.8	1,576.5	197.3	165.6	11.4	149.0	4,922.2	60,851.6
1978	2,740	1,229.1	78.6	2,434.1	6,481.8	1,377.5	131.0		101.1	62.7	740.9	693.6	149.8	[illegible]95.5	107.5	[illegible]63.7	13.0	149.0	4,285.3	63,048.1
1979	1,448	1,276.0	88.4	2,521.9	5,334.3	1,502.5	147.4		107.2	62.7	459.3	693.6	149.8	255.0	[illegible]	[illegible]	15.4	149.0	3,739.4	64,643.0
1980	1,666	1,671.3	98.2	2,585.7	6,021.2	1,[illegible]7.4	163.8		113.4	62.7	143.3	693.6	149.8	104.1	[illegible]7.9	112.6	20.3	149.0	3,527.9	67,136.3
1981		1,806.7	109.2	[illegible],685.5	4,601.4	1,752.3	176.0	.5	120.6	62.7		693.6	149.8		362.5	[illegible]26.0	22.6	149.0	3,[illegible]9.6	68,248.1
1982		1,[illegible].7	120.3	2,729.9	4,656.9	1,877.2	188.3	1.0	127.8	62.7		693.6	1[illegible].8		362.5		22.6	149.0	3,634.5	69,270.5
1983		1,806.7	131.3	2,770.8	4,708.8	2,022.7	200.6	1.4	134.9	62.7		693.6	149.8		362.5		22.6	149.0	3,799.8	70,179.5
1984		1,[illegible].7	142.4	2,807.2	4,756.3	2,168.1	212.9	1.9	142.1	62.7		693.6	149.8		362.5		[illegible]	[illegible]	3,965.2	70,970.6
1985		1,806.7	153.5	2,838.8	4,799.0	2,313.5	225.2	2.4	149.3	62.7		693.6	149.8		362.5		22.6	149.0	4,130.6	71,639.0
1986		1,806.7	164.5	2,865.6	4,836.8	2,458.9	237.4	2.9	156.5	62.7		693.6	149.8		362.5		22.6	149.0	4,295.9	72,179.9
1987		1,806.7	175.6	2,887.2	4,869.5	2,604.3	249.7	3.4	163.7	62.7		693.6	149.8		362.5		22.6	149.0	4,461.3	72,588.1
1988		1,806.7	186.6	2,903.5	4,896.8	2,749.8	262.0	3.9	170.8	62.7		693.6	149.8		362.5		22.6	149.0	4,626.7	72,858.2
1989		1,806.7	197.7	2,914.3	4,918.7	2,895.2	274.3	4.3	[illegible]	62.7		693.6	149.8		362.5		22.6	149.0	4,792.0	72,984.9
1990		1,806.7	208.7	2,919.4	4,934.8	3,040.6	286.5	4.8	185.2	62.7		693.6	149.8		362.5		22.6	149.0	[illegible]	72,[illegible]
1991		1,806.7	224.8	2,918.5	4,950.0	3,174.8	299.8	10.1	193.2	62.7		693.6	149.8		362.5		22.6	149.0	5,118.1	72,794.3
1992		1,806.7	240.9	2,911.8	4,959.4	3,309.0	313.1	15.4	201.1	62.7		693.6	149.8		362.5		22.6	149.0	5,278.8	72,474.9
1993		1,806.7	257.1	2,899.0	4,96[illegible].8	3,443.1	326.5	20.7	209.2	62.7		693.6	149.8		362.5		22.6	149.0	5,439.7	71,998.0
1994		1,806.7	273.2	2,879.9	4,959.8	3,577.3	339.8	26.0	217.1	62.7		693.6	149.8		362.5		22.6	149.0	5,600.4	71,357.4
1995	105	1,807.9	289.3	2,854.3	5,[illegible].5	3,712.2	353.1	31.3	225.1	52.7		693.6	149.8		362.5		22.6	149.0	5,761.9	70,652.0
1996		1,807.9	305.4	2,826.1	4,939.4	3,847.0	366.4	36.6	233.1	62.7		693.6	149.8		362.5		22.6	149.0	5,923.3	69,668.1
1997		1,807.9	321.5	2,786.7	4,916.1	3,949.5	379.7	41.9	241.0	62.7		693.6	149.8		362.5		22.6	149.0	6,052.3	68,531.9
1998		1,807.9	337.6	2,741.3	4,886.8	4,051.9	393.0	47.2	249.1	62.7		693.6	149.8		362.5		22.6	149.0	6,181.4	67,[illegible]
1999		1,807.9	353.7	2,689.5	4,851.1	4,131.2	406.3	[illegible]	[illegible]	62.7		693.6	149.8		362.5		22.6	149.0	6,287.2	65,801.2
2000		1,807.9	369.8	2,632.0	4,809.7	4,210.6	419.[illegible]	57.8	265.0	62.7		693.6	149.8		362.5		22.6	149.0	6,393.2	64,217.7
2001		1,807.9	387.9	2,568.7	4,764.5	4,289.9	431.5	69.7	275.7	62.7		693.6	149.8		362.5		22.6	149.0	6,507.0	62,475.2
2002		1,807.9	405.9	2,499.0	4,712.8	4,369.2	443.4	81.5	286.4	62.7		693.6	149.8		362.5		22.6	149.0	6,620.7	60,567.3
2003		1,807.9	424.0	2,422.7	4,654.6	4,448.5	455.4	93.4	297.1	62.7		693.6	149.8		362.5		22.6	149.0	6,734.6	58,487.3
2004		1,807.9	442.0	2,339.5	4,589.4	4,527.8	467.3	105.3	307.8	62.7		693.6	149.8		362.5		22.6	149.0	6,848.4	56,228.3
2005		1,807.9	460.0	2,249.1	4,517.0	4,607.2	479.2	117.2	318.5	62.7		693.6	149.8		362.5		22.6	149.0	6,962.3	53,783.0
2006		1,807.9	478.1	2,151.3	4,437.3	4,665.3	491.1	129.0	329.2	62.7		693.6	149.8		362.5		22.6	149.0	6,054.8	51,165.5
2007		1,807.9	496.1	2,046.6	4,350.6	4,723.5	503.0	140.9	339.9	62.7		693.6	149.8		362.5		22.6	149.0	7,147.5	48,368.6
2008		1,807.9	514.2	1,934.7	4,256.8	4,781.7	514.9	152.8	350.7	62.7		693.6	149.8		362.5		22.6	149.0	7,240.3	45,385.1
2009		1,807.9	532.2	1,815.4	4,155.5	4,840.5	526.8	164.7	361.3	62.7		693.6	149.8		362.5		22.6	149.0	7,333.5	42,207.1
2010	179	1,809.9	550.2	1,688.3	4,227.4	4,899.3	538.7	176.6	372.0	62.7		693.6	149.8		362.5		22.6	149.0	7,426.8	39,007.7
2011		1,809.9	566.2	1,560.3	3,936.4	4,958.2	549.7	200.7	383.9	62.7		693.6	149.8		362.5		22.6	149.0	7,532.7	35,[illegible]
2012		1,809.9	[illegible]	1,416.5	3,808.6	5,017.0	560.6	224.8	395.7	62.7		693.6	149.8		362.5		22.6	149.0	7,638.3	31,581.7
2013		1,809.9	598.2	1,263.3	3,671.4	5,051.4	571.5	248.9	407.5	62.7		693.6	149.8		362.5		22.6	149.0	7,719.5	27,533.6
2014		1,809.9	614.3	1,101.3	3,525.5	5,085.7	582.4	273.0	419.3	62.7		693.6	149.8		362.5		22.6	149.0	7,800.6	23,258.5
2015		1,809.9	630.3	930.3	3,370.5	5,120.1	593.3	297.1	431.1	62.7		693.6	149.8		362.5		22.6	149.0	7,881.8	18,747.2
2016		1,809.9	646.3	749.9	3,206.1	5,154.5	604.2	321.2	443.0	62.7		693.6	149.8		362.5		22.6	149.0	7,963.1	13,990.2
2017		1,809.9	662.3	559.6	3,031.8	5,1[illegible]9.5	615.1	345.3	454.8	62.7		693.6	149.8		362.5		22.6	149.0	8,044.9	8,977.1
2018		1,809.9	678.3	359.1	2,847.3	5,224.5	626.0	369.4	466.6	62.7		693.6	149.8		362.5		22.6	149.0	8,126.7	3,697.7
2019		1,809.9	694.3	147.9	2,652.1	5,259.6	636.9	393.5	478.4	62.7		693.6	149.8		362.5		22.6	149.0	8,208.6	-1,858.8


STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DELTA BRANCH
DELTA WATER FACILITIES
AREAS OF INVESTIGATION
SACRAMENTO-SAN JOAQUIN DELTA
DECEMBER 1961
4 0 4 8
SCALE OF MILES
LEGEND
BOUNDARY OF THE SACRAMENTO-SAN JOAQUIN DELTA (SECTION 12220 OF THE WATER CODE)
BOUNDARY OF THE WESTERN DELTA STUDY AREA (AREA OF INTENSIVE STUDY OF WATER REQUIREMENTS AND SUPPLIES, PURSUANT TO CHAPTER 1765, STATUTES OF 1959)

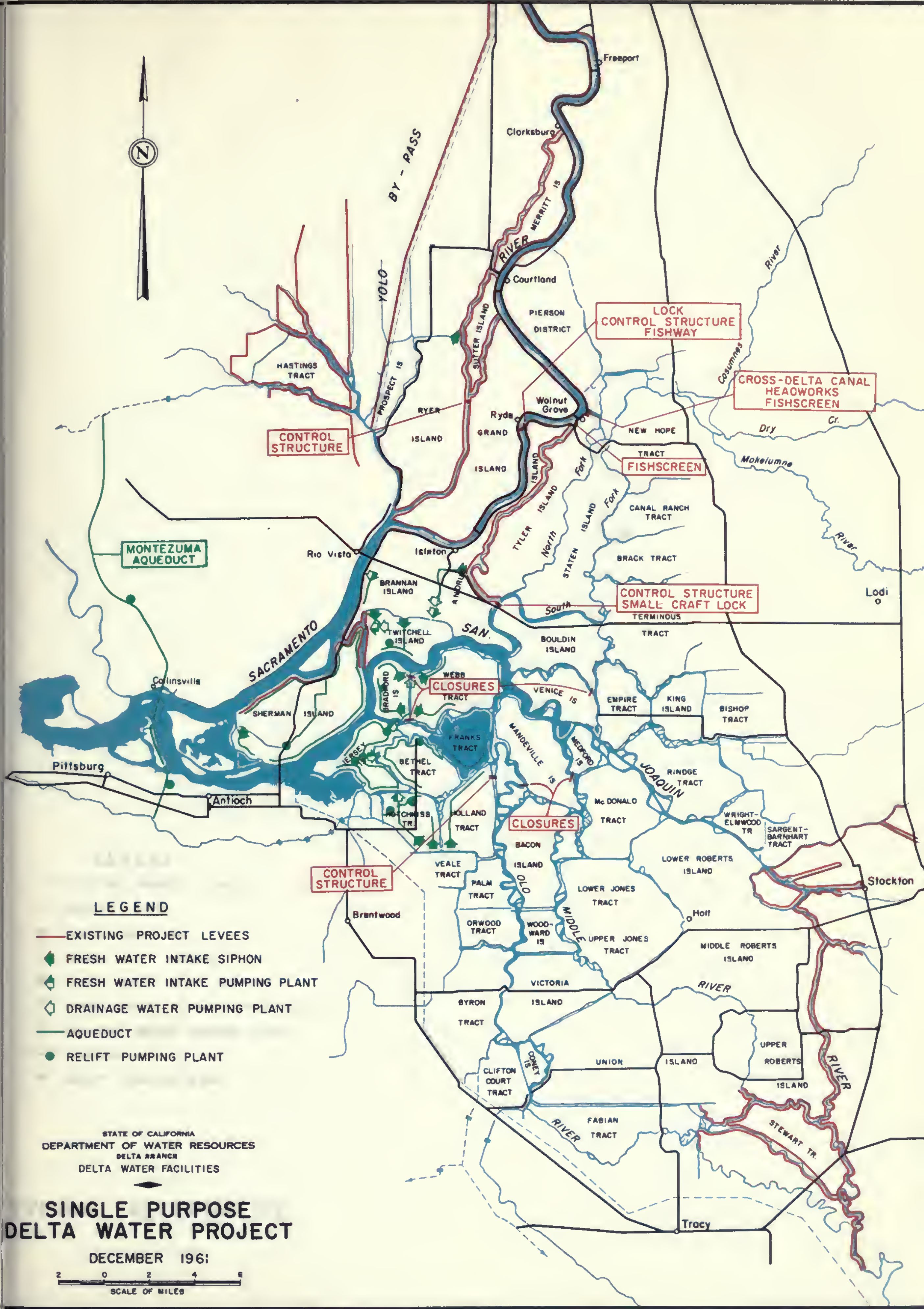




STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DELTA BRANCH
DELTA WATER FACILITIES

CHIPPS ISLAND BARRIER PROJECT

DECEMBER 1961


LEGEND
EXISTING PROJECT LEVEES
FRESH WATER INTAKE SIPHON
FRESH WATER INTAKE PUMPING PLANT
DRAINAGE WATER PUMPING PLANT
AQUEDUCT
RELIFT PUMPING PLANT
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DELTA BRANCH
DELTA WATER FACILITIES
SINGLE PURPOSE
DELTA WATER PROJECT
DECEMBER 1961
2 0 2 4 6
SCALE OF MILES
N
LOCK
CONTROL STRUCTURE
FISHWAY
CROSS-DELTA CANAL
HEADWORKS
FISHSCREEN
FISHSCREEN
CONTROL STRUCTURE
CONTROL STRUCTURE
SMALL CRAFT LOCK
CLOSURES
CLOSURES
CONTROL STRUCTURE
MONTEZUMA
AQUEDUCT
Freeport
Clarksburg
Courtland
Walnut
Grove
Ryde
Rio Vista
Isleton
Collinsville
Pittsburg
Antioch
Brentwood
Lodi
Stockton
Holt
Tracy
YOLO BY-PASS
HASTINGS
TRACT
PROSPECT IS
RYER
ISLAND
SUTTER ISLAND
GRAND
ISLAND
RIVER
MERRITT IS
PIERSON
DISTRICT
NEW HOPE
TRACT
Cosumnes
River
Dry
Cr.
Mokelumne
River
CANAL RANCH
TRACT
BRACK TRACT
TYLER ISLAND
North Fork
STATEN ISLAND
Fork
South
TERMINOUS
TRACT
BRANNAN
ISLAND
ANDRUS
TWITCHELL
ISLAND
SAN
SACRAMENTO
SHERMAN ISLAND
BRADFORD IS
WEBB
TRACT
FRANKS
TRACT
JERSEY
BETHEL
TRACT
HOTCHKISS
TR.
HOLLAND
TRACT
BOULDIN
ISLAND
VENICE IS
EMPIRE
TRACT
KING
ISLAND
BISHOP
TRACT
MANDEVILLE IS
MEDFORD IS
JOAQUIN
RINDGE
TRACT
Mc DONALD
TRACT
WRIGHT-
ELMWOOD
TR
SARGENT-
BARNHART
TRACT
BACON
ISLAND
VEALE
TRACT
PALM
TRACT
OLD
ORWOOD
TRACT
WOOD-
WARD
IS
MIDDLE
LOWER JONES
TRACT
UPPER JONES
TRACT
LOWER ROBERTS
ISLAND
MIDDLE ROBERTS
ISLAND
RIVER
VICTORIA
ISLAND
BYRON
TRACT
CLIFTON
COURT
TRACT
CONEY IS
UNION
ISLAND
UPPER
ROBERTS
ISLAND
RIVER
STEWART TR.
RIVER
FABIAN
TRACT

LEGEND

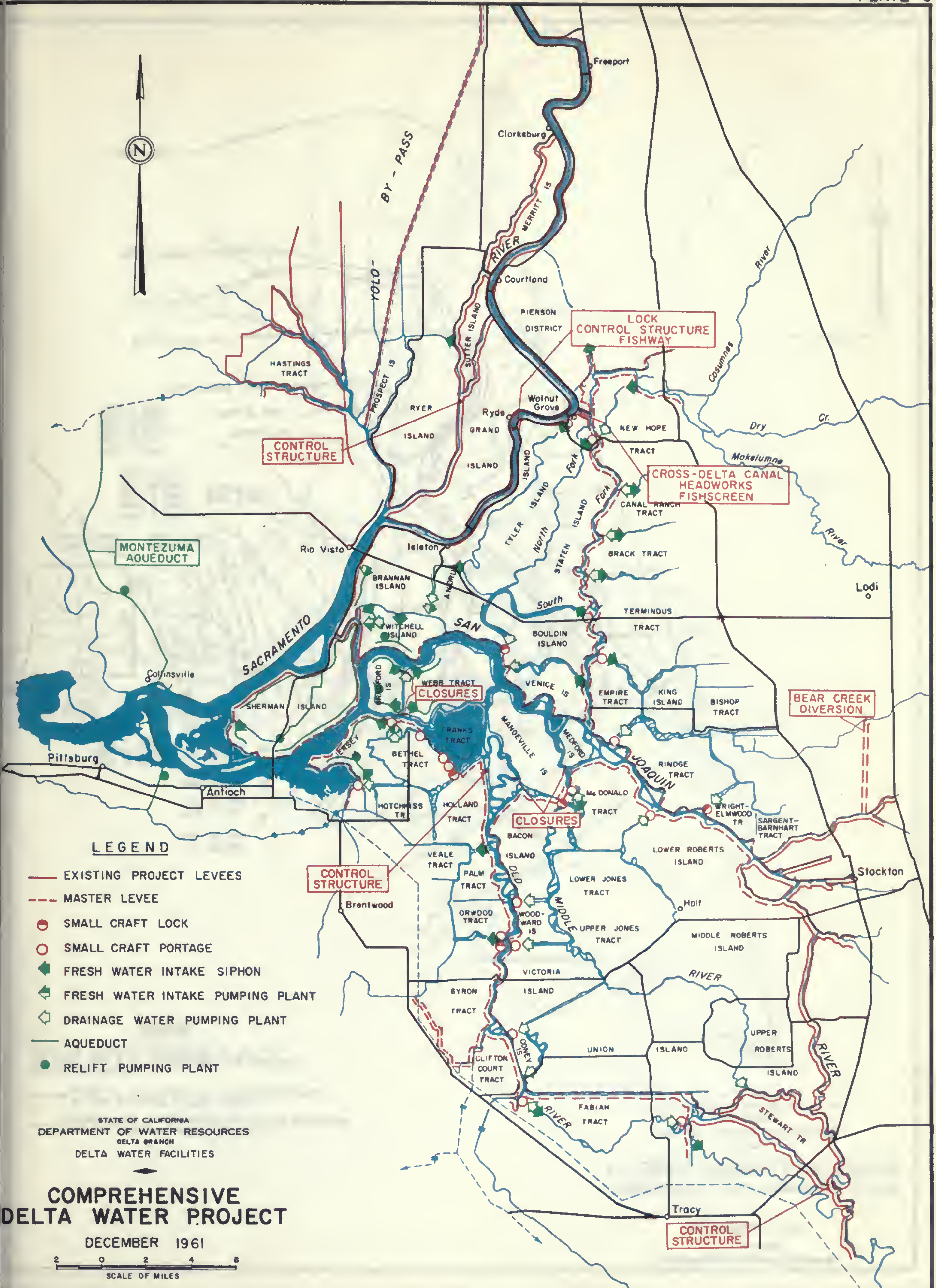
- EXISTING PROJECT LEVEES
- MASTER LEVEE
- SMALL CRAFT LOCK
- SMALL CRAFT PORTAGE
- FRESH WATER INTAKE SIPHON
- FRESH WATER INTAKE PUMPING PLANT
- DRAINAGE WATER PUMPING PLANT
- AQUEDUCT
- RELIFT PUMPING PLANT

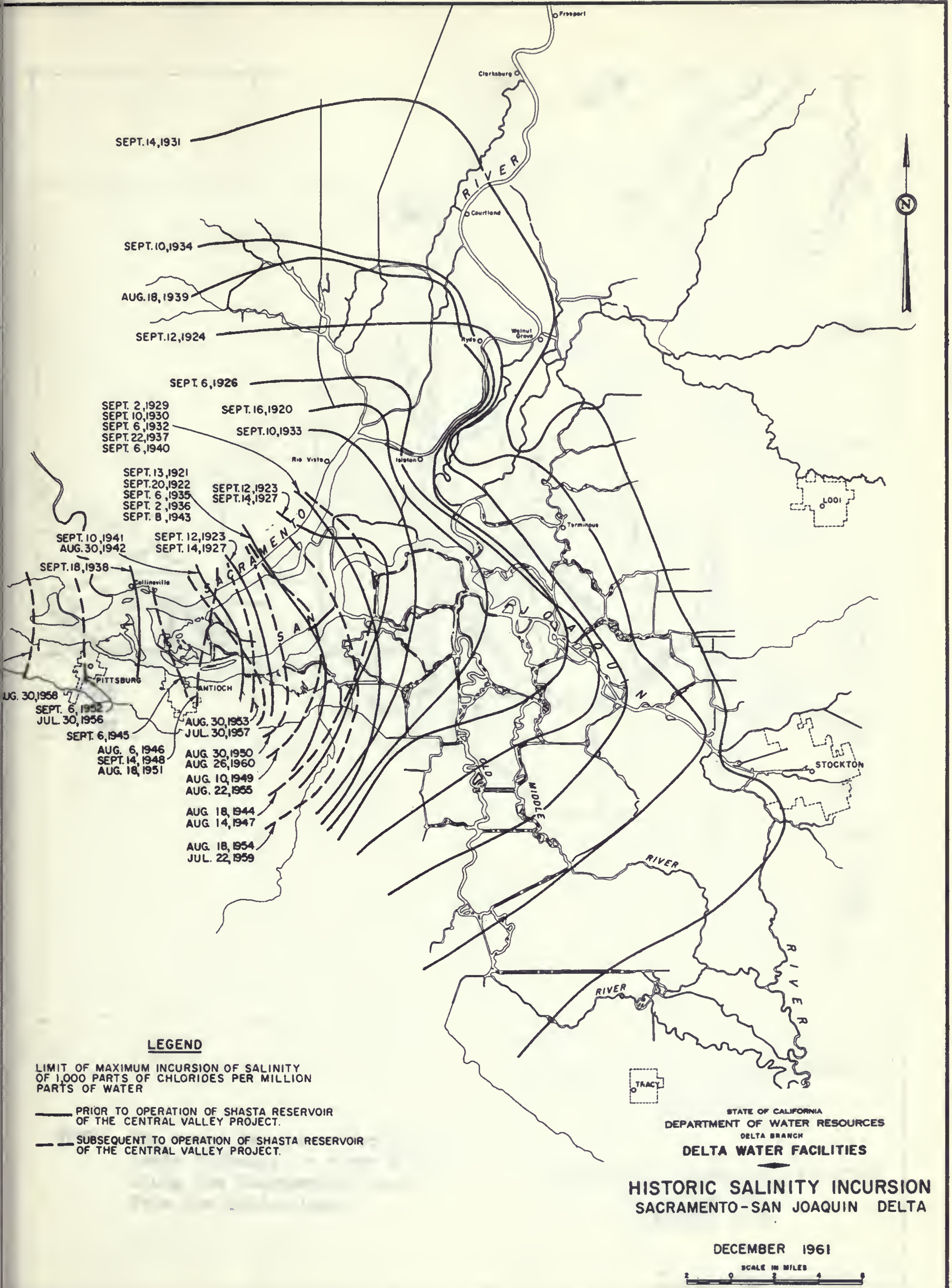
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DELTA BRANCH
DELTA WATER FACILITIES

TYPICAL ALTERNATIVE DELTA WATER PROJECT

DECEMBER 1961

2 0 2 4 6
SCALE OF MILES


N
BY - PASS
YOLO
Freeport
Clarksburg
MERRITT IS
RIVER
SACRAMENTO
Courtland
PIERSON
DISTRICT
LOCK
CONTROL STRUCTURE
FISHWAY
SUTTER ISLAND
PROSPECT IS
HASTINGS
TRACT
RYER
ISLAND
Ryde
GRAND
ISLAND
Walnut
Grove
CONTROL
STRUCTURE
NEW HOPE
TRACT
CROSS-DELTA CANAL
HEADWORKS
FISHSCREEN
CANAL RANCH
TRACT
Cosumnes
River
Dry
Cr.
Mokelumne
River
TYLER
ISLAND
North
Fork
STATEN
ISLAND
BRACK TRACT
MONTEZUMA
AQUEDUCT
Rio Vista
Isleton
BRANNAN
ISLAND
ANDRUS
South
TERMINOUS
TRACT
Lodi
TWITCHELL
ISLAND
SAN
BOULDIN
ISLAND
Collinsville
BRADFORD IS
WEBB TRACT
CLOSURES
VENICE IS
EMPIRE
TRACT
KING
ISLAND
BISHOP
TRACT
BEAR CREEK
DIVERSION
SHERMAN
ISLAND
FRANKS
TRACT
MANDEVILLE IS
MEDFORD IS
JOAQUIN
RINDGE
TRACT
Pittsburg
JERSEY
BETHEL
TRACT
Antioch
HOTCHKISS
TR
HOLLAND
TRACT
Mc DONALD
TRACT
CLOSURES
WRIGHT-
ELMWOOD
TR
SARGENT-
BARNHART
TRACT
BACON
ISLAND
LOWER ROBERTS
ISLAND
VEALE
TRACT
CONTROL
STRUCTURE
PALM
TRACT
OLD
LOWER JONES
TRACT
Stockton
Brentwood
ORWOOD
TRACT
WOOD-
WARD
IS
MIDDLE
UPPER JONES
TRACT
Holt
MIDDLE ROBERTS
ISLAND
VICTORIA
ISLAND
RIVER
BYRON
TRACT
UPPER
ROBERTS
ISLAND
CONEY IS
UNION
ISLAND
RIVER
CLIFTON
COURT
TRACT
FABIAN
TRACT
RIVER
STEWART TR
Tracy
CONTROL
STRUCTURE
LEGEND
EXISTING PROJECT LEVEES
MASTER LEVEE
SMALL CRAFT LOCK
SMALL CRAFT PORTAGE
FRESH WATER INTAKE SIPHON
FRESH WATER INTAKE PUMPING PLANT
DRAINAGE WATER PUMPING PLANT
AQUEDUCT
RELIFT PUMPING PLANT
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DELTA BRANCH
DELTA WATER FACILITIES
COMPREHENSIVE
DELTA WATER PROJECT
DECEMBER 1961
2 0 2 4 6
SCALE OF MILES



LEGEND

LIMIT OF MAXIMUM INCURSION OF SALINITY OF 1,000 PARTS OF CHLORIDES PER MILLION PARTS OF WATER

——— PRIOR TO OPERATION OF SHASTA RESERVOIR OF THE CENTRAL VALLEY PROJECT.

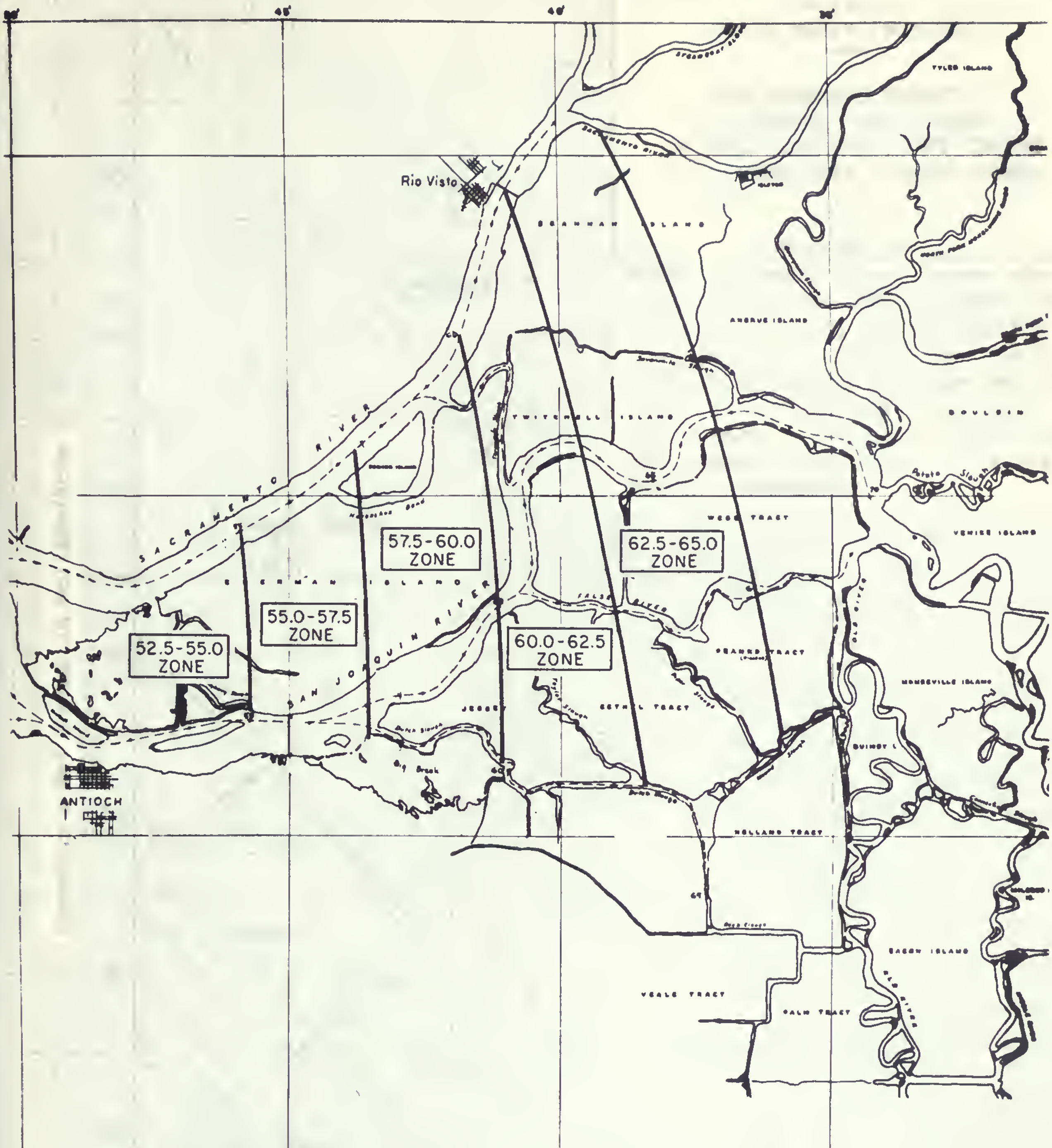
— — SUBSEQUENT TO OPERATION OF SHASTA RESERVOIR OF THE CENTRAL VALLEY PROJECT.

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DELTA BRANCH
DELTA WATER FACILITIES

HISTORIC SALINITY INCURSION
SACRAMENTO-SAN JOAQUIN DELTA

DECEMBER 1961

SCALE IN MILES
2 0 2 4 6

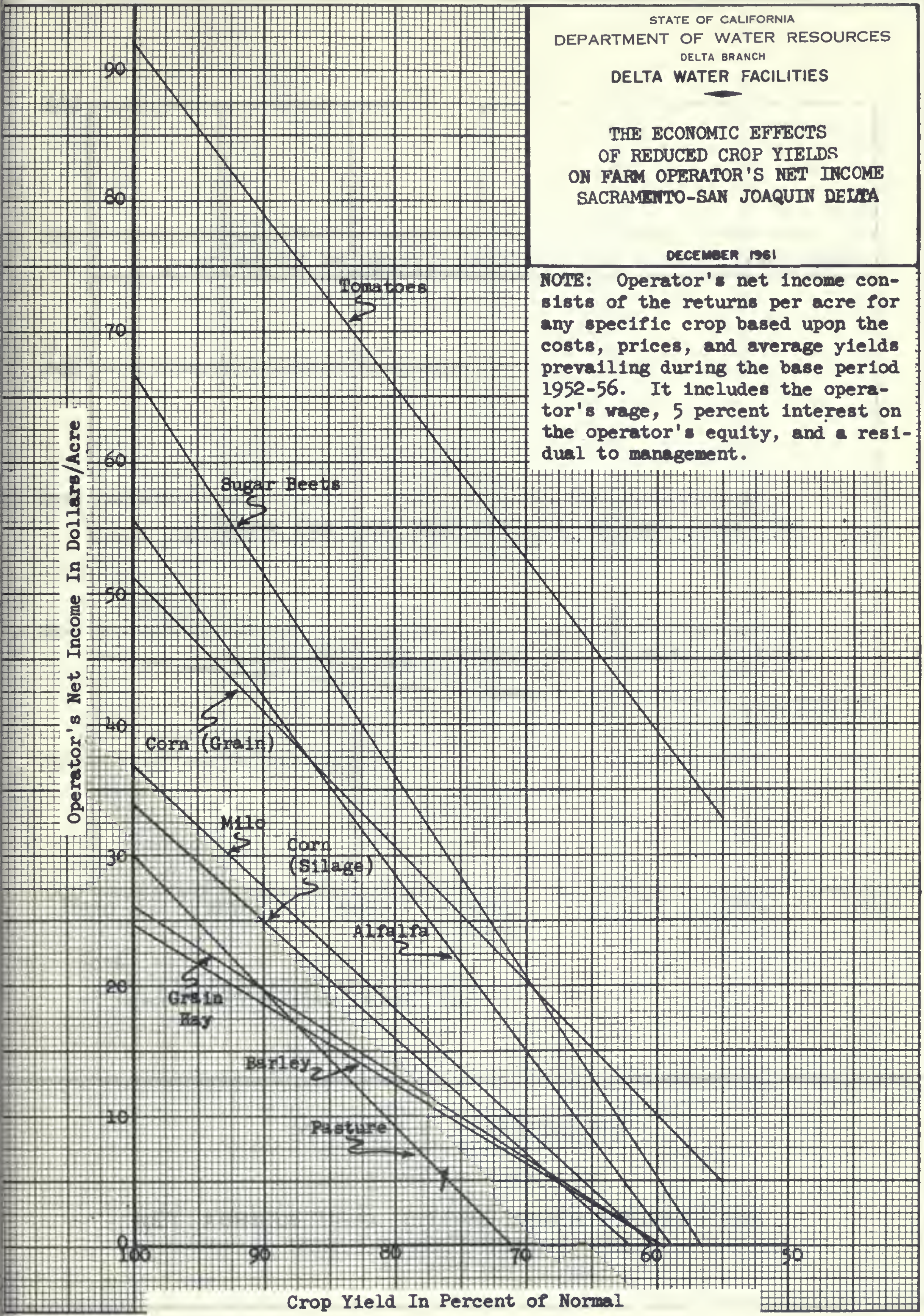


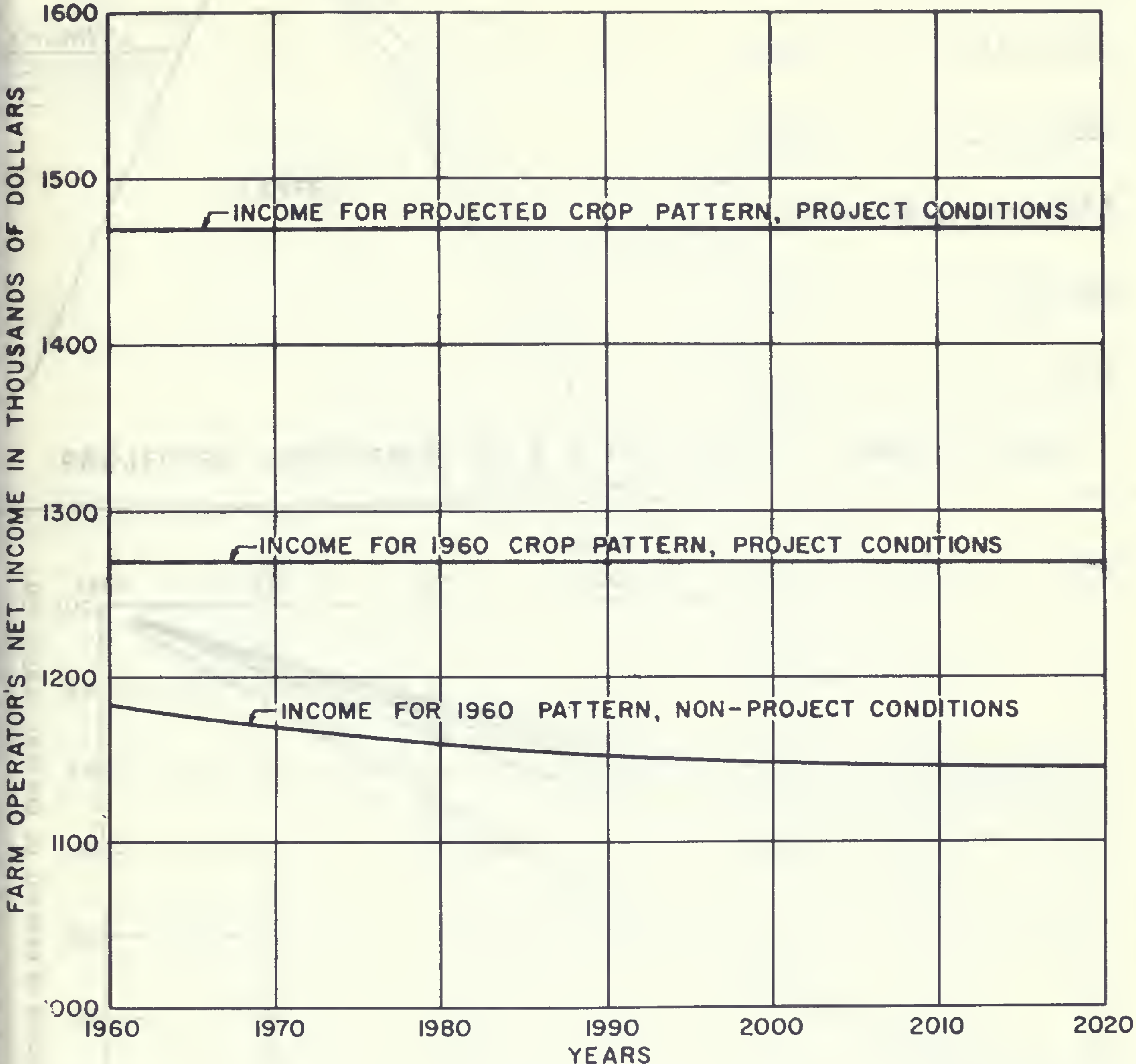
NOTE: The zones designate the approximate distance in river miles along the Sacramento River from the Golden Gate.

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DELTA BRANCH
DELTA WATER FACILITIES

AGRICULTURAL WATER QUALITY ZONES WITHIN THE WESTERN DELTA

DECEMBER 1961


STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DELTA BRANCH
DELTA WATER FACILITIES
THE ECONOMIC EFFECTS
OF REDUCED CROP YIELDS
ON FARM OPERATOR'S NET INCOME
SACRAMENTO-SAN JOAQUIN DELTA
DECEMBER 1961
NOTE: Operator's net income consists of the returns per acre for any specific crop based upon the costs, prices, and average yields prevailing during the base period 1952-56. It includes the operator's wage, 5 percent interest on the operator's equity, and a residual to management.
Tomatoes
Sugar Beets
Corn (Grain)
Milo
Corn (Silage)
Alfalfa
Grain Hay
Barley
Pasture
Operator's Net Income In Dollars/Acre
90
80
70
60
50
40
30
20
10
0
Crop Yield In Percent of Normal
100
90
80
70
60
50



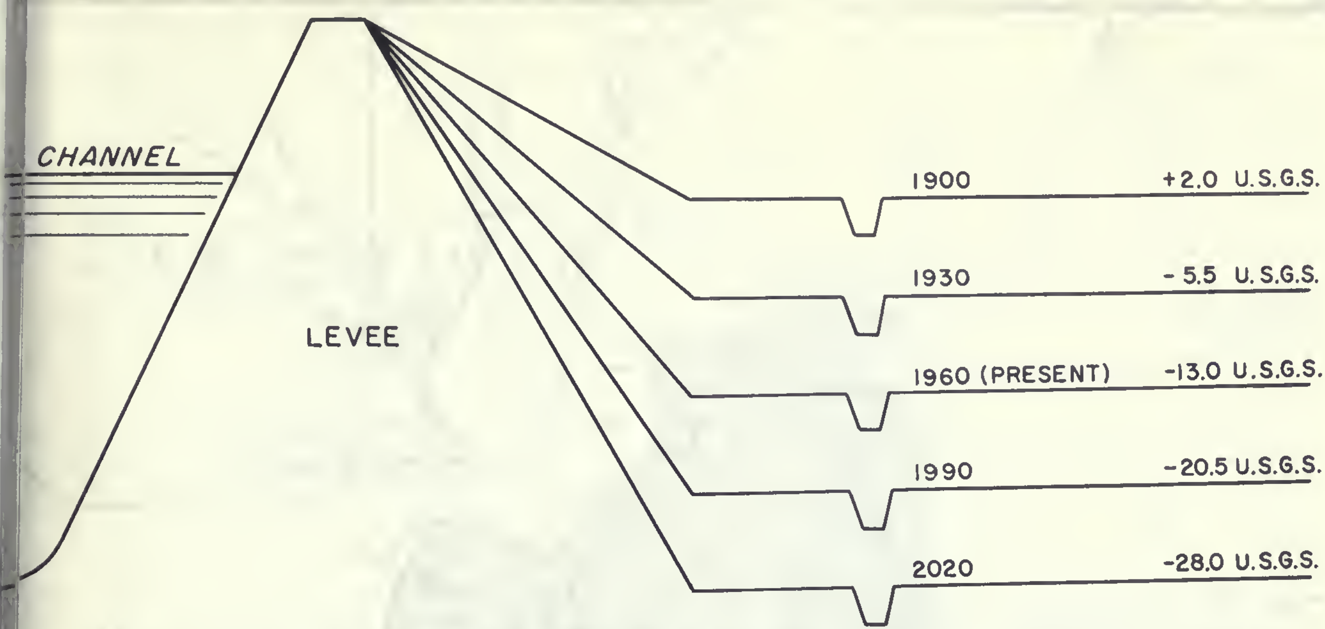
NOTE:
WESTERN DELTA STUDY AREA INCLUDES 38,400 ACRES OF AGRICULTURAL LANDS.

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DELTA BRANCH

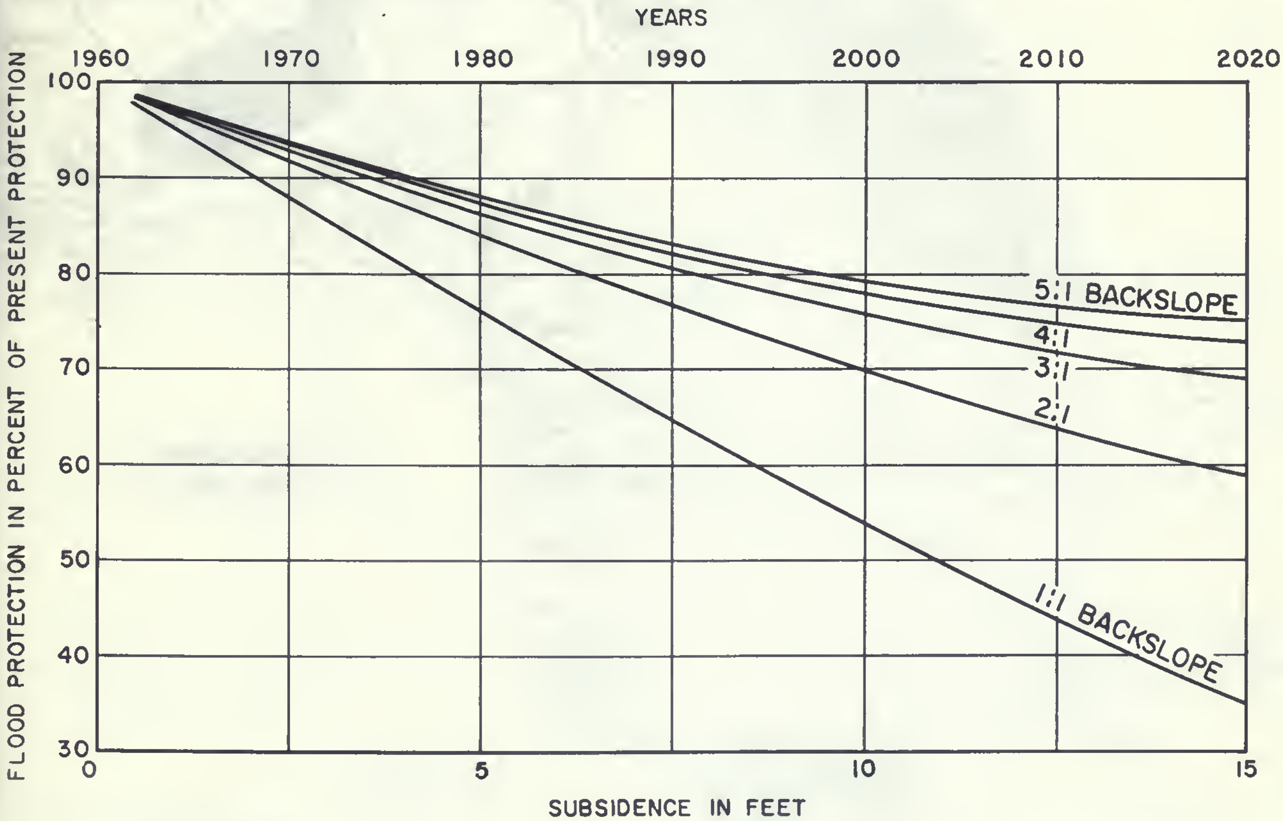
DELTA WATER FACILITIES

NET AGRICULTURAL INCOME UNDER PROJECT AND NON-PROJECT CONDITIONS

DECEMBER 1961



PROJECTED SUBSIDENCE OF A TYPICAL DELTA LOWLAND AREA
(NOT TO SCALE)



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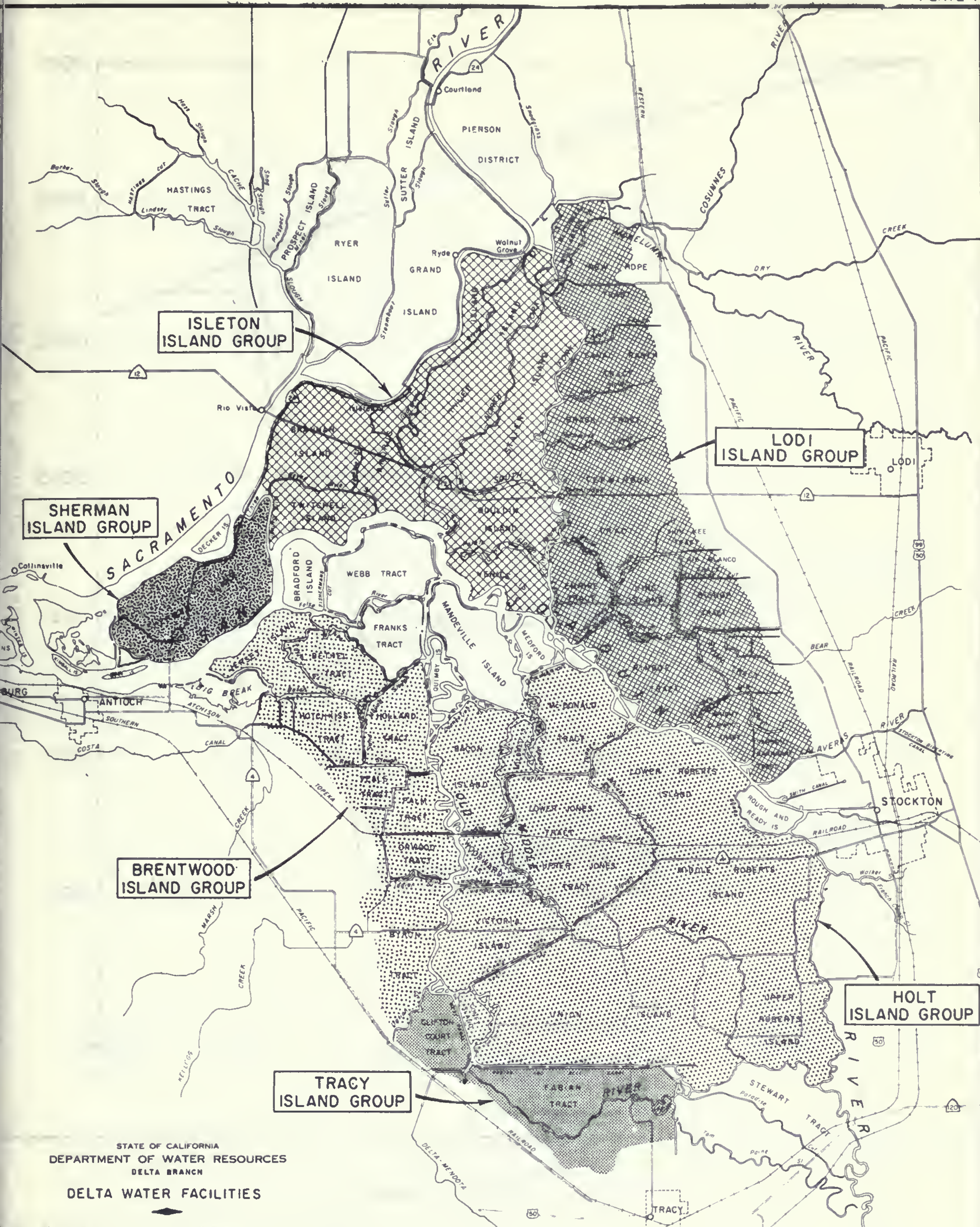
DEPARTMENT OF WATER RESOURCES
DELTA BRANCH
DELTA WATER FACILITIES

SUBSIDENCE AND ITS RELATION TO LEVEE STABILITY

DECEMBER 1961



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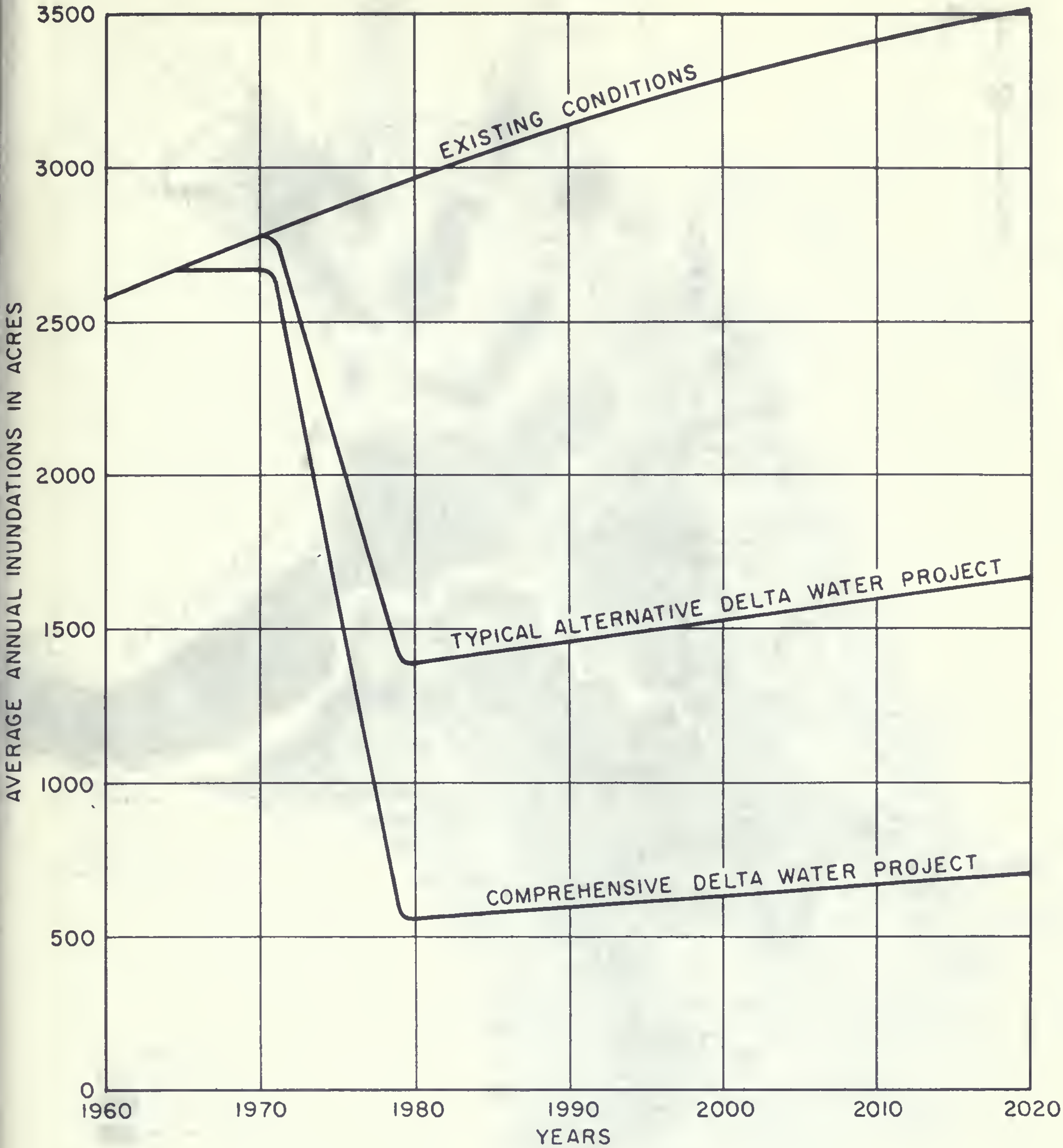
DELTA BRANCH

DELTA WATER FACILITIES

LOCATION OF ISLAND GROUPS
SACRAMENTO-SAN JOAQUIN DELTA

DECEMBER 1961

SCALE OF MILES
2 0 2 4 6



STATE OF CALIFORNIA
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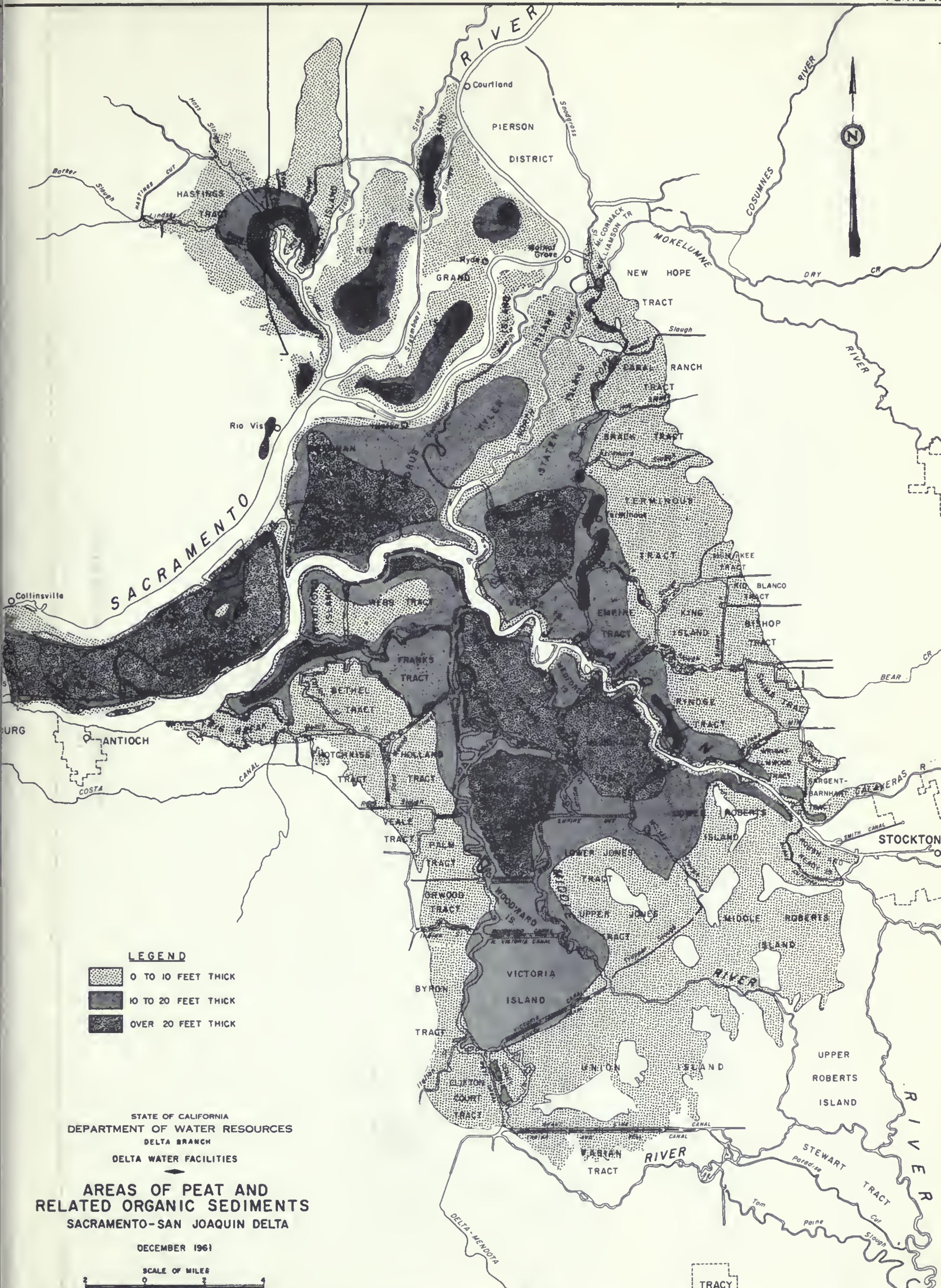
DELTA BRANCH

DELTA WATER FACILITIES

PROJECTED AVERAGE ANNUAL INUNDATIONS
SACRAMENTO-SAN JOAQUIN DELTA
DECEMBER 1961



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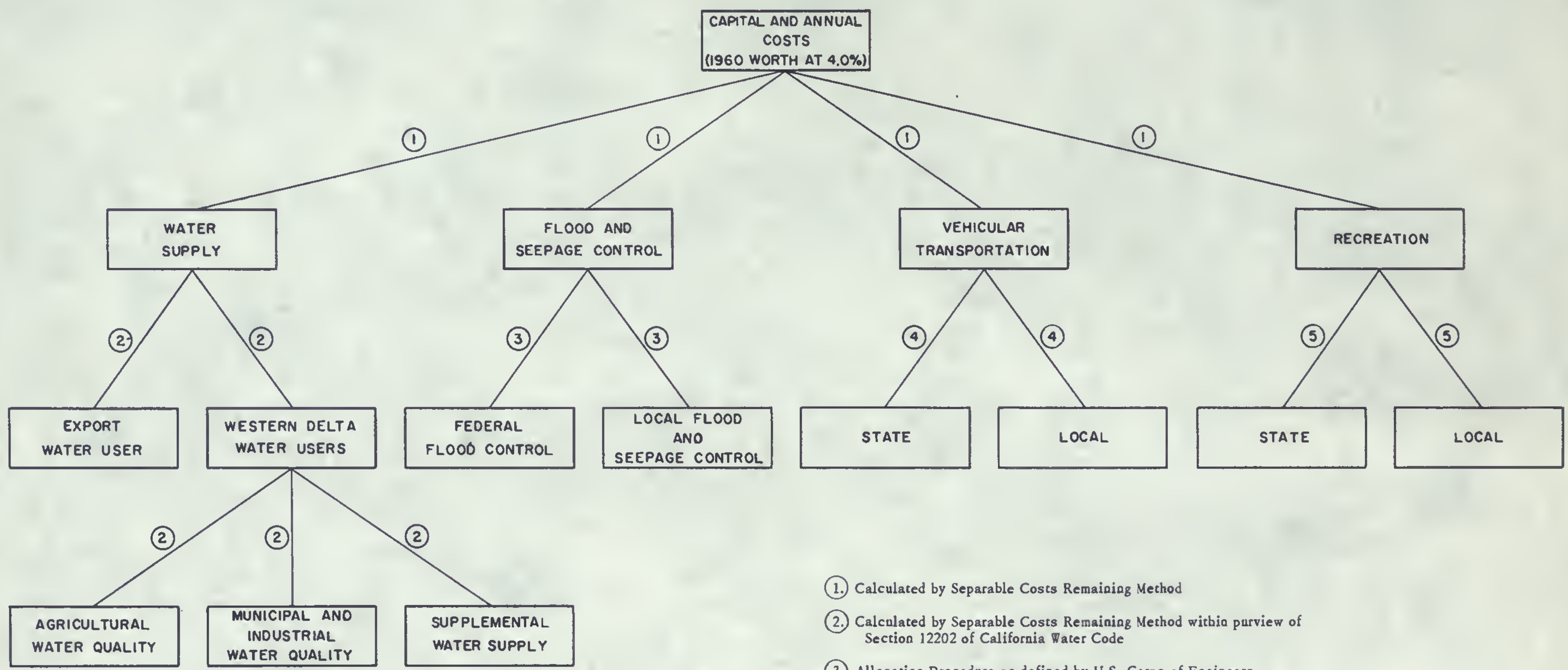
DEPARTMENT OF WATER RESOURCES
DELTA BRANCH
DELTA WATER FACILITIES

AREAS OF PEAT AND RELATED ORGANIC SEDIMENTS
SACRAMENTO-SAN JOAQUIN DELTA

DECEMBER 1961

METHODS OF COST ALLOCATION



1. Calculated by Separable Costs Remaining Method
2. Calculated by Separable Costs Remaining Method within purview of Section 12202 of California Water Code
3. Allocation Procedure as defined by U.S. Corps of Engineers
4. Allocation based on benefits
5. Allocation based on recommended DWR policy of nonreimbursable recreation costs